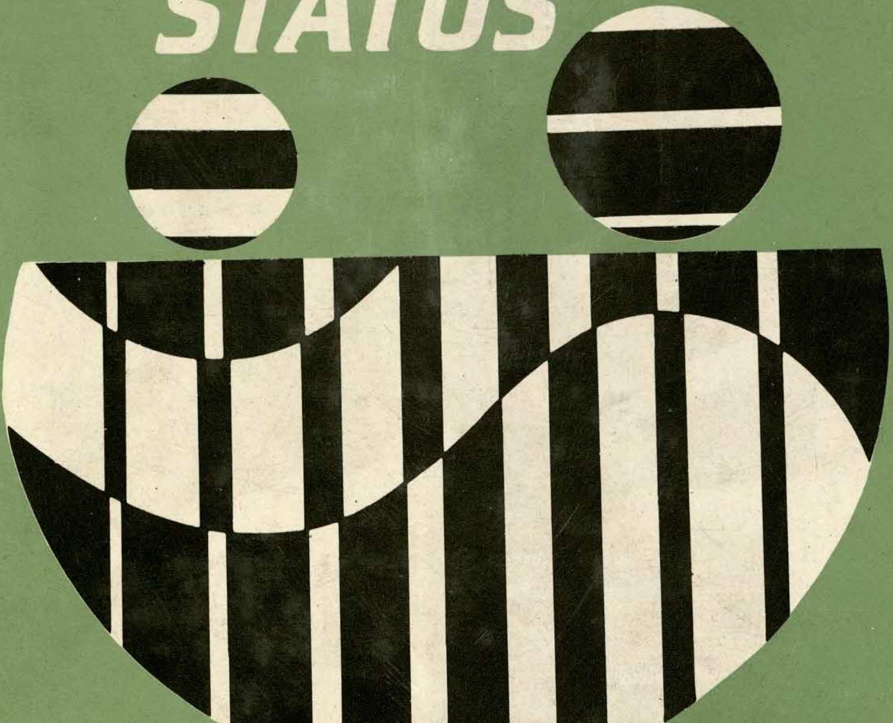
ECOLOGY, GROWTH AND NUTRITIONAL STATUS



SAMVIT S KAUL

ISAAC K NYAMONGO

Nutrition, growth, health and population change are all closely related concerns today. Biological and biocultural anthropologists working in developing countries recognize these concerns as central to the adaptive success of population in these regions. Malnutrition, a critical health problem of childhood in these countries, is widely accepted as the primary factor in poor body growth. Other factors that are crucial to growth process include disease prevalence, health status and life history. All these factors of environment operate as part of an eco-system and involve complex interaction with other components.

Growth and development is a meaningful barometer of the environmental influences especially of the nutritional status, not only of the present state of nutrition, but also of the past. In the control of malnutrition, early detection of growth failure is vital for immediate action on nutritional, cultural and (or) economic constraints. Growth monitoring is a better means for primary health care activities, and is an indicator of progress and of better health. Also, follow-up studies assume greater significance in these undertakings since they provide a measure of efficiency and involve rather simple and low-cost technologies.

Growth monitoring may not be prestigious, but it is a sensitive tool and an indicator of how balanced the social and economic aspects of development are. The present study will be useful to Administrators, Social Workers and Anthropologists, etc.

ISBN 81-7024-286-X

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UBSPD

UBS Publishers' Distributors Ltd
8/1-B, Chowringhee Lane, Calcutta-700 016
Ph:212451, 249473

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ASHISH PUBLISHING HOUSE
8/81, Punjabi Bagh, New Delhi

Published by :

S.B. Nangia
for **Ashish Publishing House**
8/81, Punjabi Bagh
New Delhi-110 026

Tele. 50 05 81
541 09 24

ISBN 81-7024-286-X

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1990

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Typesetting by :

Cambridge Printing Works,
B-85, Naraina, Phase II,
New Delhi-110 028
Phone - 587039

Printed at
Efficient Printers
Naraina
NEW DELHI

Acc no-16712

Preface

Nutrition, growth, health and population change are all closely related concerns today. Biological and biocultural anthropologists working in developing countries recognize these concerns as central to the adaptive success of population in these regions. Malnutrition, a critical health problem of childhood in these countries, is widely accepted as the primary factor in poor body growth. Other factors that are crucial to growth process include disease prevalence, health status and life history. All these factors of environment operate as part of an ecosystem and involve complex interaction with other components.

Growth and development is a meaningful barometer of the environmental influences especially of the nutritional status–not only of the present state of nutrition, but also of the past. In the control of malnutrition, early detection of growth failure is vital for immediate action on nutritional cultural and (or) economic constraints. Growth monitoring is a better means for primary health care activities, and is an indicator of progress and of better health. Also, follow-up studies assume greater significance in these undertakings since they provide a measure of efficiency and involve rather simple and low-cost technologies.

Growth monitoring may not be prestigious, but it is a sensitive tool and an indicator of how balanced the social and economic aspects of development are. The present study on the Kisii children of school-going ages in western Kenya, a developing country of Africa, views child growth in conjunction with ecological background, and aspects of socio-economic and socio-cultural environment. The pattern of growth of Kisii children is compared with that of the surrounding populations of East Africa as well as the NCHS standards. The findings point to such factors as educational status of parents and ecological variables as type of residence, sources and treatment of drinking water, health facilities, customs, etc. as contributing factors to poor nutritional status of Kisii children.

We have received immense assistance from several people in carrying out the investigation. Grateful thanks are due to the President, the Republic of Kenya for allowing this study to be carried out in Kenya (vide Research Permit no. : OP. 13/001/18C-17/2, dated : February 15, 1988). Thanks are due to Dr. Jackton Nyamongo of the Kenyatta Medical Hospital, Dr. David Nyamwaya of the African Medical Research Foundation (AMRF), the staff of the Keroka Health Centre, various school authorities and the subjects for valuable assistance during the collection of data in the field. Thanks are also due to the Chairman, Department of Anthropology at the Panjab University for extending necessary facilities in carrying out this work.

The authors appreciate the help and encouragement given by Dr. R.K. Sapru of the Panjab University and Mr. S.B. Nangia at the Ashish Publishing House. The involvement of Hemant and Sumant in all aspects of the production of the book is deeply appreciated.

Chandigarh
October 15, 1989

S.S. Kaul
I.K. Nyamongo

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1

Introduction

Growth, an exceedingly regular process, refers to the continuous addition in body dimensions of an organism over a period of time. It differs significantly from development which refers to the attainment of functional maturity over a period of time. Nutritional and other environmental stresses affect development of an individual to the extent that some or all milestones of developmental achievement are greatly delayed. These delayed periods can be seen on X-rays, especially of the long bones, as transverse lines (also known as Harris lines) of arrested growth (Blanco *et al.*, 1974). A casual look at velocity curves for certain body dimensions indicates that the rate of change of any one parameter, say body height, is not constant, there are times when such changes are very large and others when they are small.

Normal growth and development of every living organism is a function of both genetic and environmental factors. At the same time, growth and maturity rates of children are very sensitive to environmental stresses (Malcom, 1975, that is, child growth is ecosensitive (Haas, 1983). Thus, Johnston *et al.* (1985) note that, "While one cannot ignore the existence of hereditary factors in growth, there is ample evidence which demonstrates that, in less advantaged environments, the growth status of children is a direct indicator of their environmental history and, hence, a valid indicator of the quality of the environments to which they have been exposed". Any changes in the status quo of, for instance, nutritional supplies causes physiological adjustments which lead to changes in growth rate and the rate of attainment of maturity. If the environment is conducive and able to supply all the necessary nutrients an organism will require, only then will such an organism be able to express fully its genetic potentiality. This implies that genetic factors are interwoven with the environmental conditions.

In general, before adolescent period the rate of growth is fairly high (Jenkins, 1984) and this requires adequate supplies of proteins for body building carbohydrates for supply of energy and fats which also supply energy. Carbohydrates are the most easily available and economical source of energy, atleast in the developing countries. Fats, on the other hand, provide more than twice the energy (38.9 KJ/g) released by proteins or carbohydrates when taken weight for weight. However, one drawback is that comparatively fats are more expansive to obtain than are carbohydrates. This very factor forces many people to prefer carbohydrates over fats as a source of energy. In addition to its high energy reserves, dietary fat has two functions that are essential to human nutrition (Nestle, 1981) : it acts as a solvent for the absorption of fat–soluble vitamins (the vitamins in question here are A, D, E and K); and it also provides the essential fatty acids–those that cannot be synthesised in adequate amounts for optimal body function.

During adolescence, repeated or long-endured episodes of nutritional stresses may influence significantly future growth and development (Jenkins, 1984 and Stini, 1969), indeed it may result in death especially in the young actively growing children if the stresses are severe (Newman, 1977). Males are more easily disturbed by such environmental stresses than are females but also they respond better when these stresses disappear and conditions turn favourable (Malina *et al*., 1985). As a result of such stresses the growth curves are pushed off their normal routes. If the stresses are not persistent for long this deviation may only be temporary resulting in a reduced growth rate, but as these stresses are removed the growth rate increases so as to get back to its expected trajectory line. At times such rapid growth may be thrice the normal growth rate at that age. It has been referred to as "compensatory growth" by nutritionists (Harrison *et al*., 1977).

Growth retardation, as a result of anomalies in food supplies and/or food utilisation, is a common feature in many of the developing countries. Growth performance is relatively good upto about 4-6 months of age, perhaps due to the reason that the infant depends mainly on maternal food supplies, namely breastfeeding. Curves of average weight-for-age are commonly below the 10th percentile and very often close to the 3rd percentile of reference weight curves (DeMaeyer, 1976). Indian children studied from poor communities in Chandigarh (Bedi, 1975) fall below the 3rd percentile on the Harvard standard charts (Stuart and Stevenson, 1963) both for height and weight. The well-to-do Indian children, however, when put on the Harvard standard charts fall somewhere around the 50th percentile for height and weight (Vijayaraghavan *et al*., 1971). It follows that the effects of food supply and nutrition on childhood growth are the central problems of the developing world which have caught the attention of Biological (Physical) Anthropologists. This is because the effects of environmental stress and change are central problems in biological anthropology today.

In the remaining part of this chapter it is worth the while to review issues of childhood growth, food supply and nutrition with reference to the developing countries. This draws upon extensively from the detailed and excellent review of Huss-Ashmore and Johnston (1985).

Growth and Development

Reference Data

Physical growth of children is widely recognized as one of the more sensitive and reliable indicators of health and nutritional status in human populations (Johnston, 1981a). Patterns of growth and development of children and youth have been described for most world regions.

A controversial issue in the study of the growth of children and youth in developing countries concerns the selection of an appropriate data set to serve as a reference in the evaluation of growth. Though many investigators refer to such a set of "reference standards", the data are not intended to be a "norm"– *i.e.*, a standard to be attained. Rather, reference data are measures to which growth may be compared. The controversy arises over whether to use (*a*) a single international set of reference data, or (*b*) local data, likely to be ethnically and geographically more similar to the study of population than an international standard would be. This issue has been discussed by a number of authors (*e.g.* Goldstein and Tanner, 1980; Habicht *et al.*, 1974; Jackson and Jackson, 1984; Johnston, 1985; Johnston, *et al.*, 1984a; Kaul, 1983; and Waterlow *et al.*, 1977).

It is important to remember that not all samples qualify as reference data. Reference values are not simply data of convenience, but are precise estimates of the means, the standard deviations, and the percentiles of the appropriate age and sex categories of a well-defined population (Johnston, 1985). The numbers of individuals in each category should be large enough and the statistical procedures sufficiently reliable to ensure that values at least as far from the mean as the 5th and 95th percentiles are estimated accurately. It is general belief that means (and associated standard deviations and/or centiles) calculated on the basis of a few hundred children covering some particular age range can serve as the norms or standards of growth (Kaul, 1983). The question of adequate samples at each age is an important aspect of the construction of growth standards. In constructing cross-sectional standards the number of children to be measured in each age group has to be nearly proportional to the rate at which growth takes place. Major studies of this kind sample about 1000 children of each sex in each age group. It has been pointed out that this number produces useful though slightly imprecise centiles, while samples of less than about 300 in each age group are unsuitable as cross-sectional standardizing series (Jordan *et al.*, 1975; Eveleth and Tanner, 1976). Various problems of planning and execution of growth surveys designed to construct national standards are discussed by Jordan *et* *al*. (1975) and recommendations for analysing and presentation of data for international use are presented by Waterlow *et al*. (1977).

Many investigators have suggested that local samples, geographically and ethnically similar to the group being evaluated, should be used to provide reference values. By and large, such contentions result from a belief that differences in growth status among populations reflect, to a significant degree, genetic differences. Local standards of reference are seen to provide a better control over these genetic factors.

Theoretically speaking, Huss-Ashmore and Johnston (1985) believe that an evaluation of growth status should be based on reference values reflecting shared climatic, historical, and ethnic determinants. However, the tasks of obtaining reference data that fulfil the necessary criteria is a formidable one. Virtually all who have considered this topic in its complexity have agreed that more is lost by relying on poorly constructed standards, derived from inadequate samples drawn from undefined population groups, than by the careful use of a single international set of reference values (Johnston, 1985).

The efforts required to produce reference data are beyond the resources of all individual investigators and most nations. The data set most widely accepted as an international standard of reference is therefore that of the US National Centre for Health Statistics (Hamill, *et al*., 1977). The NCHS data are based upon a national probability sample of children and youth from the continental United States with numbers in each age/sex cell ranging from 300 to 1600. Furthermore, the percentiles have been developed by smoothing techniques involving a cubic spline function. Virtually all international bodies concerned with growth assessment have recommended that the NCHS data be used as an international reference standard (International Union of Nutritional Sciences, 1971).

Descriptive Studies

One of the major on-going studies of childhood growth in a developing country has been conducted in Guatemala City. From its beginning in 1953, this study has examined longitudinally the children and youth attending several schools in Guatemala City. The schools have been selected to provide a cross-section of the school-attending population, from the highest SES to the urban poor. Because of its design, and because of the large number of subjects followed serially, this study provides a unique opportunity for the description and comparison of the growth of children of different SES levels within a developing country. In particular, this study permits the examination of the growth of a large sample of children and youth from a developing country who, as a group, are free of the stresses affecting the poor of such countries. Johnston *et al*. (1973) presented descriptive statistics for the upper SES component of this population : (*a*) height and weight, by sex, between 6 and 17 years; and (*b*) whole year velocities, centred on age as well as on peak velocities. Additional data are available for height and weight (Bogin and MacVean, 1978; Bogin and MacVean, 1981; Johnston *et al*., 1975a and 1976) and for body composition (Bogin and MacVean, 1981; Johnston, 1985; Johnston *et al*., 1984a and Johnston *et al*., 1975b). Together these studies indicate that upper-class Guatemalan school children, as would be expected, are taller, weigh more, and have greater stores of fat and lean tissue than their lower–SES age and sex peers.

Furthermore, the growth of children in the upper-class samples is comparable to that of those in North American or European reference data. This suggests that the lower body size and smaller fat and muscle stores of the poor of developing countries are environmental in origin.

There is a continuum of body size in Guatemalan children according to the adequacy of their environments (*e.g.,* Bogin and MacVean, 1978). Johnston *et al.* (1984b) have compared the heights and weights of five samples of Guatemalan 7 year olds. Two school samples are from the American school study. A third was drawn from a disadvantaged community on the outskirts of Guatemala City composed of refugees from the earthquake of 1976 (Johnston *et al.*, 1985). Sample four was semi-urban, from an indigenous Indian community located a few kilometres from the capital. The fifth, a rural sample, consisted of Ladino children from the countryside to the east of Guatemala City who were part of a nutritional supplementation study sponsored by the INCAP (Nutrition Institute of Guatemala and Panama). There was a clear and consistent gradation in the means of both males and females, from the high SES sample through the rural group.

Further insight into the growth of children from developing countries has been provided by Malina and his colleagues in the Oaxaca valley, Mexico, This project has focused on measures of body size, composition and maturation, and their relationships to environmental and secular variables (Buschang and Malina, 1983;

Himes *et al.*, 1976; Malina and Chumlea, 1980; and Malina *et al.*, 1977). Zapotec-speaking children from a marginal agricultural community in the valley are among the smallest reported for Mexico, and are significantly smaller than either rural Ladino or urban residents (Buschang and Malina, 1983). Furthermore, the rural sample is larger in body size than the urban one, indicating that, in this instance, migration to the city has not resulted in improved growth (Malina *et al.*, 1982).

Data on the growth and development of children from elsewhere in the world do not provide the comprehensiveness over time, combined with adequate sample sizes and sub-sample variability, that is found in the Guatemala City and Oaxaca projects. Much of the less-current existing data are summarized by Eveleth and Tanner (1976).

Recent descriptions of the growth of Southeast Asian children have been reported by Olness *et al.*, (1984) and Bailey *et al*. (1984). Olness and her colleagues measured the heights and weights of 1650 Indo-Chinese children, 9 months to 13 years old, living in Lao and Cambodian refugee camps and surrounding Thai villages. Children from the camps were generally free of acute illnesses. These measurements were compared to the NCHS data (1977), as well as to published data on village children of "Low or average economic status" from northern Thailand.

The children had small body sizes. Weights for heights were also below the US reference. Compared to village children from northern Thailand, the refugee groups showed some reduction in body size.

Bailey and his colleagues have reported on a longitudinal study of over 1000 infants and children from 29 villages in Thailand's northern Chang Mai province. The villagers are described as socio-economically homogeneous and free of marked food shortages (Bailey *et al.*, 1984). The rice consumed in the villages has been fortified with amino acids, thiamin, Vitamin A, and iron. Compared to the NCHS data, the children grew in body length between the 5th and 10th percentiles until 18 months, falling considerably below the 5th percentile thereafter. Weight and head circumference showed a similar pattern, although the differences from the NCHS values were not as great.

Data on body composition followed a similar pattern, with triceps skinfolds initially below the 3rd percentile relative to British reference data, climbing to the 25th-50th in early childhood, and then dropping back to the 10th-25th percentiles from ages 4 through 9. In a subsequent paper, Bailey *et al.* (1985) report that, after infancy, subscapular fat is added more rapidly than triceps fat, a phenomenon similar to what has been reported for other northwestern populations.

Studies from other regions of the developing world also reveal a spectrum of small body size, reduced fat and lean tissue stores, and in some instances, a low weight-for-height ratio (Yarbrough *et al.*, 1975). Delayed growth, relative to NCHS reference data, has been reported by El-Nofely (1978) for Nubian children and by Sukkar *et al.* (1980) for rural Sudanese children from Khartoum. These two studies also reported reduced skinfold thickness and, for the sample from Khartoum, a median menarcheal age of 14.0 calculated by probit analysis. Menarche occurred 1-1.5 years later than is usually observed in developed nations.

Similar findings are reported for Sub-Saharan Africa (Hiernaux, 1970; Little *et al.*, 1983; and Rea, 1971), India (Hauspie *et al.*, 1980; ICMR, 1972; and Kaul, 1975), and South America (Graham *et al.*, 1980). On a world basis, Meredith (1969) has compared the body size of 8-year-olds from different regions; as expected, samples drawn from developing countries reveal smaller means.

Factors Responsible for Growth Variation

The growth of children and youth of developing nations is reduced relative to their age and sex peers from developed nations. This reduction is minimal in the first postnatal year, but then growth falls off sharply through 3 years, followed either by a parallel course or even a slight catch-up, depending upon the measurement and the sample. Linear measures are affected more than are measures of body mass and composition, and males are generally affected more than females. Maturation rates, indicated by either skeletal age or the age at menarche, are likewise affected, indicating that developing country children grow less and mature more slowly than children comprising the international reference standards. Greater differences are seen when measures are related to age (*e.g.*, height-for-age) than when other indices are used (*e.g.*, weight-for-height). This indicates that children from developing countries are proportionately smaller than their peers from either developed nations or upper-SES groups in their own country.

Hereditary and Environmental Factors

Environmental factors strongly regulate growth in body size and composition and the rate of biological maturation (Fiawoo, 1975 and Malcom, 1975). In contrast, genetic determinants of body shape and proportion are more resistant to the environment. While environmental components of growth in shape can be demonstrated, the body proportions characteristic of ethnic groups seem to maintain themselves across a range of environmental conditions.

Evidence for the importance of the environment has come from several studies that used different designs. In one of the earliest, Habicht *et al.* (1974) analysed the differences between mean height and weight of pre-school children from a number of published studies. The differences among high-SES samples from developed and developing countries showed a range of variation of 3% in height and 6% in weight. In contrast, the differences between high-and low-SES samples within developing countries showed a range of 12% in height and 30% in weight. Habicht *et al.* (1974) concluded that differences between samples reflected environmental factors associated with SES and that ethnic differences in growth potential were, on a global basis, minor.

Johnston *et al.* (1976) reported on a longitudinal analysis of the growth in height of a sample of Guatemalan children. All subjects were from the highest level of Guatemalan society. The sample was subdivided into individuals of Guatemalan ancestry and those of European and North American heritage who had lived in Guatemala for their primary and secondary school years. A third group, taken from the literature, consisted of children of North American ancestry. Growth records were fitted to a double logistic model, permitting the estimation of a number of parameters of growth for each individual. Of all parameters, however, differences were found in only two, growth during childhood and during adolescence. The Western European/North American children growing up in Guatemala differed from their genetically similar US peers in the amount of growth during childhood, but not in growth during adolescence. Johnston *et al.* (1976) interpreted these results as supporting the study of Habicht *et al.* (1974), indicating that growth during childhood at that SES level was regulated by environmental factors. However, population genetic factors seemed to predominate during adolescent phase.

In a third study, Frisancho *et al.* (1980) examined this issue in Quechua and Mestizo children living in a single community in Peru at an altitude of 1320 m. Within each group, subjects were classed as being of either good or poor nutritional status, and height was compared between nutritional status groups (matched for ethnicity) and between ethnic groups (matched for nutritional status). The results were similar to those of Johnston *et al.* (1976). During childhood, nutritional status differences were four to five times greater than differences by ethnicity. During the adolescent years, however, only a two–to threefold differential was observed.

Taken together, these studies, according to Huss-Ashmore and Johnston (1985), "indicate that growth differences between groups reflect environmental factors during childhood. However, during the adolescent years, genetic factors play a role and cannot be ignored. Adult size results from a blend of hereditary and environmental factors, though environmental determinants predominate".

Other studies find the environment crucial in the regulation of growth. Included among these are the many conducted around the world which have measured changes through time in the size of children (and adults) of the same age. Increasing body size has been documented over the past century in Europe and North America (Meredith, 1976; and Tanner, 1966). While other factors may contribute, the overwhelming weight of evidence indicates that environmental changes, especially improved health care and increased calorie intake (Van Wering, 1981a & b) are responsible for this trend. This is also evident in parts of the developing countries where overall economic development has brought about improvement in general living conditions of the people (Kaul and Corruccini, 1989; Sidhu *et al.*, 1982; and Singh and Malhotra, 1988). On the other hand, in developing countries, the few relevant studies conducted among the disadvantaged have failed to reveal a significant secular trend (Himes and Malina, 1975; and Himes and Mueller, 1977).

Some authors have approached the problem of the regulation of growth by the analysis of heritability for human body measurements, derived from parent/offspring correlations (Mueller, 1976). They have postulated that, where the environments are poor, heritabilities would be reduced due to an increase in the environmental component of the variability (see Mueller, 1976 for a review). However, Martorell *et al.* (1977) found no reductions in parent-child or sib-sib correlations of malnourished Guatemalan children compared to those reported for European samples. Likewise, in their study of growth in a rural Colombian village, Mueller and Titcomb (1977) found no reduction in such correlations, despite the fact that the villager suffered from suboptimal nutriture. Mueller and

Titcomb hypothesised that the existence of a correlation between offspring and parental environments would keep the heritability values high, even though the growth dimensions in question were affected by the environment. This hypothesis was supported by a study of the correlation of measurements at birth of Taiwanese siblings (Pollitt and Mueller, 1982). Each mother had received a nutritional supplement during the pregnancy of the second sibling, but not the first. A control sample, where no supplementation had occurred, was also analysed. Correlations were reduced where supplementation was a factor, suggesting importance of the correlation of parental and offspring environments.

Environmental Factors

The role of disadvantaged environments in the small body size of inhabitants of developing countries seems well established. Furthermore, the crucial period for long-term environmental effects seems to be the years of childhood. Among the environmental factors that have been identified nutrient intake is crucial to the growth process. The malnutrition so prevalent in the developing world is widely accepted as the primary factor in poor growth. Environmental components operate as part of an ecosystem, and the pathways by which they affect growth involve complex interactions with other components (Cravioto *et al.*, 1967).

Socioeconomic status composed of many factors *e.g.*, nutritional status, disease prevalence, health status, and life history, almost universally correlated to growth; infact, growth status is frequently used as an indicator of socioeconomic inequity (Bielicki and Welon, 1982). In developing countries, socioeconomic correlates of growth have been demonstrated for urban Guatemalan children (Bogin and MacVean, 1978; 1981; and 1983). Compared to upper-SES samples, lower-SES school children were smaller, had smaller stores of fat and muscle, and showed reduced IQs.

Similar findings come from other regions. Among rural Colombians, adults of higher-SES show a slower reduction in stature with ageing than those of lower status (Himes and Mueller, 1977). Socioeconomic factors in growth in other populations have been reviewed by Susanne (1980). Among African and Asiatic populations the relationship between socioeconomic status and the prevalence of severe nutritional problems is evident (Chang *et al.*, 1963; Ashcroft *et al.*, 1966; Sabharwal *et al.*, 1966; Bailey, 1970; Rea, 1971; Raghavan *et al.*, 1971; Amirhakimi, 1974; and Bogin and MacVean, 1978). Children with signs of protein-calorie malnutrition have a significantly lower growth rate in height and weight compared to apparently normal children of those with Vitamin B complex deficiency (Rao and Satyanarayana, 1976).

Rea (1971) presented clear evidence of socioeconomic influences on the growth of children in Lagos under 5 years of age : Three socioeconomic groups were included, at all ages and in both sexes the differences for weight and height were in the directions to be expected from the socioeconomic differences. There was failure of growth in all groups aged between 3 and 18 months. In populations where breastfeeding is customary, babies grow normally during the first few months of life. Between 3 and 18 months, however, a phase of nutritional inadequacy is observed (Susanne, 1980). Breastfeeding may continue for a year or more but is not nutritionally sufficient for the whole of this period. Consequently, mortality and morbidity rates increase and protein and/or calorie malnutrition is more common, especially during the 2nd year. The slowing of growth during this age range is less marked in higher socioeconomic groups. After 18 months of age, there is slight recovery towards more normal growth.

Eveleth and Tanner (1976), reviewing data for children of low or high socioeconomic level from many countries, concluded that growth retardation usually begins at about 6 months of age.

Seasonal variations related to growth among children from developing countries have also been reported. In the Oaxaca study, Malina and Himes (1977a & b) have reported a seasonality of births and deaths. The seasonal distribution of births seems to reflect annual agricultural cycle. The distribution of mortality indicated a particular risk associated with the rainy season. However, the major component of the seasonal distribution was in excess of deaths due to gastrointestinal disorders among 1-4 year-olds. There was no seasonal component in infant mortality, presumably due to the protection afforded by breastfeeding. Seasonal effects associated with the rainy seasons have also been shown in rural Taiwan (Adair and Pollitt, 1983) and Gambia of West Africa (Billewicz and McGregor, 1982).

Migration status may also affect growth, largely through differences in socioeconomic status and its nutritional and health correlates; but the data are not clear. In their study of Guatemalan City children, Bogin and MacVean (1981) found that children of rural-born parents were shorter than those whose parents were urban-born, but children with one parent born in the city and one in the rural area were the tallest of all. In this study the length of time the migrant parents have lived in the city was not controlled.

Infectious disease, so prevalent in developing countries, is in theory an important factor in growth. However, most of the research purpoting to demonstrate a relationship is confound by one or more problems : (*a*) the synergistic effects of nutrition and disease are not controlled (Scrimshaw *et al.*, 1968); (*b*) disease episodes are recorded from retrospective reports without identification of the responsible pathogens; and/or (*c*) many analyses are rendered invalid by failure to control for unreported periods. Nevertheless, the available research does suggest an effect of disease upon growth that is independent of a concomitant reduction in nutrient, or the nutritional effects (McGregor *et al.*, 1968). Episodes of diarrhoeal disease are associated with reduced growth especially in weight. This has been reported for Guatemala (Martorell *et al.*, 1975a), Mexico (Condon-Paoloni *et al.*, 1977), Belize (Jenkins, 1982), Taiwan (Baumgartner and Mueller, 1984), and Bangladesh (Black *et al.*, 1984).

The synergistic relationship of malnutrition and disease has been investigated by Martorell *et al.* (1980), who examined the effects of illness upon dietary intakes of malnourished Guatemalan children. The presence of common symptoms of disease was associated with a reduction of nearly 20% in estimated food intake, equivalent to 175 kilocalories and 4.8 g Protein. This suggests that infections have a marked impact upon nutritional status in children of developing countries.

Nutrition and Malnutrition in Developing Countries

Many books and articles in the popular and scientific press attest to the ubiquitous nature and numerous effects of human malnutrition in developing countries (Aggrawal, 1986; Balderston *et al.*, 1981; Brozek and Schurch, 1984; Cravioto *et al.*, 1974; Moss and Mayer, 1977; Suskind, 1977; and Wurtman and Wurtman, 1977). Current work in Asia, Africa and Latin America is aimed at documenting (*a*) traditional diets and their effects and (*b*) the causes and consequences of dietary change. In addition, anthropologists have joined nutritionists and public health personnel in their search for the causes of childhood malnutrition.

Almost all societies in the developing world today base their subsistence on agriculture or an agro-pastoral adaptation. For most, the food production system now contains both traditional elements and elements of modernisation. The latter may show up as changes in agricultural technology (ploughs and tractors), changes in marketing strategy, and changes in crops or other products produced. The introduction of cash cropping, and the linking of pastoralists to international markets has in many cases profoundly affected local diets (Dewey, 1981; Harvey and Heywood, 1983; and Teitelbaum, 1977). While some of these changes are positive-increasing crop yields and household incomes–others appear to have had a negative effect on overall nutritional status.

The Assessment of Nutritional Status

Nutritional status refers to the state of nutriture of an individual or a specific group. The term may refer to a specific nutrient (*e.g.*, Zinc) or to a class of nutrients (as in the assessment of PEM) and may apply to either nutritional deficiency or excess (Jelliffe, 1966; Jelliffe and Jelliffe, 1979; and Simopoulos, 1982). Nutritional status may be assessed in a laboratory, using precise instrumentation, or in the field, utilising other appropriate methods.

Biological anthropologists have most frequently used field methods in assessing nutritional status. The methods tend to focus either upon the evaluation of dietary intake or upon the measurement of growth and body composition status (*i.e.*, nutritional anthropometry). Methods of evaluating dietary intake have been discussed by Messer (1984) and Quandt (1986).

Nutritional anthropometry is recognised widely as an effective means of assessing nutritional status, especially at the level of the population. The measurements taken are used to assess either physical growth (a reflection of nutrient adequacy during development (Tanner, 1976)) or body composition (an indicator of the excess or deficit of energy and protein (Frisancho, 1974)).

Height and weight evaluated against age are most often used to indicate nutritional status. Deviations from the reference value are usually expressed in one of the three ways : (*a*) as a percentage of the mean; (*b*) as a Z-score (*i.e.*, a standard score); or (*c*) as a percentile. The percentage of the mean, frequently used (McLaren and Read, 1972), is difficult to interpret, since the s.d. of the measurements differ by age. Though some workers utilise percentile values, which permit the classification of an individual, without a programme for estimating exact values, such percentiles are only approximations of relative size and cannot be manipulated statistically (Waterlow, 1984). Z-scores are thus, according to Huss-Ashmore and Johnston (1985), the most useful descriptive statistics for the children of developing countries.

Of the anthropometric indices available, weight-for-height is used most frequently. Although it is useful as a measure of wasting in acute malnutrition (Waterlow, 1984), it is not a sensitive indicator of chronic undernutrition, since in this condition both weight and height tend to be affected similarly. Some investigators have used the ratio of head circumference to chest circumference in assessing nutritional status (Jelliffe, 1966). However, in a study of Ladino Guatemalan children, Martorell *et al*., (1975b) found this ratio "to have no power to discriminate either populations or individuals who are well nourished or moderately malnourished".

Reference data are available for evaluating body composition from anthropometry. For skinfolds of children and youth, NCHS data have been presented by Johnson *et al*., (1981), while Frisancho (1981) has published NCHS data for skinfolds and arm muscle circumference and area for a broader age range, 1-75 years.

Malnutrition and Growth

The effects of malnutrition upon growth, and by extension upon adult body size, have been investigated by many researchers. Their studies have focused upon alternations of the growth process as a result of both chronic and acute PEM and upon the functional outcomes of those alterations. Researchers have turned increasingly to analytic techniques such as principle components or path analysis in their attempts to differentiate among correlated determinants (*e.g.*, Baumgartner and Mueller, 1984; Frisancho, 1984; Johnston, 1981b and Johnston *et al*., 1980a).

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Compared to children from nutritionally sound environments, children from developing country environments associated with chronic undernutrition display impaired growth and development (Jenkins, 1981; and Scholl *et al.*, 1979) and body composition (Bogin and MacVean, 1981), as well as the interrelationships between variables (Garn *et al.*, 1983).

The long-term biological response of humans to malnutrition during infancy and childhood is a topic of interest to bioanthropologists. Anthropological theory tends, in general, to emphasize adaptive responses of human populations to environmental stresses, through evolutionary, developmental, or cultural mechanisms. This theoretical stance has been carried by some workers into their nutritional studies in developing countries (*e.g.*, Adair, 1985; and Adair *et al.*, 1983). Stini (1969 and 1975) suggested that the altered growth patterns of populations under nutritional stress may be termed adaptive since they improve the chances for survival. Observations from his study in Colombia support this contention. First, a reduction of mean adult male body weight of 15% (70-60 kg) represents an energy saving of approximately 33% (3243-2351 Kcal). Second, the savings may be even more, since the reduction is relatively greater in estimated protein stores than in body weight. Finally, males show a greater reduction than do females, which Stini interprets as adaptive in that the males, who are larger than females, could have their body size reduced without "serious loss of productivity".

Frisancho *et al.* (1973) have supported this view in a study of a low-SES community on the outskirts of Cuzco, Peru. They found a greater proportion of surviving offspring for mothers who were below the sample's height mean than for those above the mean. The authors suggested that small body size is adaptive in adverse environments. However, they stressed the need for prospective studies.

The issue of body size and malnutrition has been approached prospectively by Scholl and her associates (Scholl, 1975; and Scholl *et al.*, 1979) in one-year cohort of children from a rural Mexican village. The children were examined monthly from birth through 36 months, and every 4 months until 7 years. The authors tested two hypotheses : first, that clinically severe PEM (*i.e.*, Kwashiorkor or Marasmus) in the second and third years of life would be more likely among children who at 6 months were larger than among the smaller children, who were growing more slowly. The second hypothesis was that clinically severe PEM would be more frequent among children with chronic mild-to-moderate PEM.

The first hypothesis was rejected. The second was accepted. Children who developed severe PEM were significantly more likely to come from the group with chronic malnutrition. The authors concluded that small body size could not be shown to be adaptive. Other studies from Guatemala (Martorell *et al.*, 1981) have failed to support the hypothesis of small body size as adaptive. Reddy *et al.* (1976) investigated functional parameters involved in resistance to infection in children with varying grades of nutritional status. Shorter children were shown to have altered cell-mediated immune responses and impaired phagocytic function.

Thus the adaptive significance of small body size is still an issue. Physiological adaptive responses enable chronically malnourished populations to survive under their typical environmental conditions, but small body size characteristic of such populations is associated with functional deficits. As a result, the numerically small differences in growth, body size, and body composition documented by biological anthropologists and others are valid indicators of adverse environments and impaired physiological and behavioural function (Huss-Ashmore and Johnston, 1985).

Factors Influencing Nutritional Status

Traditional Diets

The causes of nutritional imbalance in the developing world are complex (Mata, 1977). There is currently some question whether food systems in these areas have always been subject to failure or whether present nutritional problems are a legacy of colonial and postcolonial policy. Recent work suggests that dietary imbalance may be less a problem of the inherent productive capacity of traditional food systems than of poor storage, maldistribution, and unplanned dietary change (Berg, 1981; Dumont and Cohen, 1980; and Pellett, 1982). There is evidence that despite occasional shortfalls, indigenous food systems left undisturbed can provide relatively well-balanced diets in sufficient quantity to meet the needs of the human population (Gaulin and Konner, 1977). Such systems may have developed over time as rational adaptations to local environmental and technological limitations. Nutrient balance in traditional systems is maintained partly by a complementary mix of cultigens and partly by the inclusion of wild plant and animal foods (Fleuret and Fleuret, 1980). In either case, diversity of dietary sources seems to be a key to maintaining nutritional balance (Huss-Ashmore and Johnston, 1985).

Many of the best known examples of diets based on complementary domesticates involve a mix of grains and legumes, or the addition of animal protein to diets based on grain or tubers (Farb and Armelagos, 1980; and Haas and Harrison, 1977). For example, the indigenous New World diet of maize, beans, and squash is generally considered nutritionally sound; the other components compensate for the vitamin and amino acid imbalances of the staple maize. Similarly, the wheat-pulse-yoghurt diet of the Near East and portions of India and the manioc-fish diet of the Amazon basin can provide a balanced human diet (Dufour; 1984; Gross, 1975; and Pellett, 1976). Current problems of malnutrition in these societies are connected to larger ecological and economic problems, such as environmental degradation, drought, and resource inequalities attendant on an emerging cash economy.

An important element in maintaining the viability of many traditional agricultural systems is access to wild foods. In habitants hunt small game, fish, and gather wild plant foods (Linares, 1976; Nietschmann, 1972; Reichel-Dolmatoff, 1976; and Schlegel and Guthrie, 1980). Of these, plant resources probably make the most important contribution to human diet. Leaves, stems, and inflorescence of various plants, either wild or cultivated, are widely used as ingredients in relishes, soups, and stews that supplement the staple diet (Fleuret and Fleuret, 1980; Huss-Ashmore, 1980; and Newman 1980). These provide important nutrients otherwise missing in the diet, including significant amounts of protein, calcium, Iron, and Vitamins (Oomen and Grubben, 1981). In many cases, they have been shown to be more nutritionally valuable than the imported vegetable crops introduced by development officials. Among agricultural and pastoral peoples, the role of wild plants as famine foods has been well documented (Fleuret and Fleuret, 1980). However, many species are also part of the daily diet in these societies (Berlin and Markell, 1977; Eder, 1978; Fleuret, 1979; Grivetti, 1979; Huss-Ashmore, 1984; Messer, 1984; Schlegel and Guthrie, 1980; Teitelbaum, 1977; Waldemann, 1980; and Woolfe *et al.* (1977).

While traditional food systems have generally been thought to provide adequate human diets, they are not without problems. Periodic famines have affected a wide variety of subsistence societies (Cox, 1980; and Torry, 1984) and continue to do so. Many such societies experience seasonal shortfalls in food supply (Annegers, 1973; Chambers *et al.*, 1981; Galvin, 1984; Hausman and Wilmsen, 1984; Huss-Ashmore, 1984; and Waldemann, 1973). This "hungry season" often occurs during the preharvest period when agricultural labour requirements are high. The studies of Fox (1953) and Haswell (1953) in Gambia and of Hunter (1967) for Northeast Ghana show a significant loss in body weights of both adults and children at that time. While it is argued by some authors that the hungry season is merely a matter of monotonous or less desired diet (Ogbu, 1973; and Richard, 1983), the seasonal weight loss of small children can have serious effects on their growth and development, as well as their continued survival (Cohen and Clayden, 1978; Schofield, 1974; and Spencer and Heywood, 1983).

Some traditional diets have been shown to have dystrophic effects. Amounts of phytate in grain-based diets have been held accountable for specific zinc deficiency syndromes (Berlyne *et al.*, 1973; and Ronaghy and Halsted, 1975). Toxic effects have also been demonstrated for diets high in oxalates or lathyrogens (Strong, 1976). While these can interfere with mineral absorption and bone formation, their effects are less noticeable than those of other dietary toxins. Cyanogenetic glycosides, present in manioc and lima beans, have been implicated in some forms of tropical blindness and neural degeneration seen in West Africa, Jamaica, and Malaya. Using an animal model, Jackson and Jackson (1984) have shown that the cyanide content of the Liberian manioc-based diet is sufficient to cause growth and behaviour retardation, altered glucose metabolism, depressed thyroid activity, and haematological disturbances. Katz (1982) has suggested that manioc consumption in the presence of the sickle-cell gene may be a positive adaptation to malarial conditions.

The adequacy of traditional diets also depends upon the degree to which humans can adapt to chronic low levels of energy and nutrient intake. Ample evidence supports the contention that humans adapt to both low and fluctuating energy intake by changing their energy requirements (Apfelbaum *et al.*, 1971; Ashworth, 1968; Crowdy *et al.*, 1982; Durnin *et al.*, 1973; Edmundson, 1977; 1979; 1980; FAO/WHO, 1978; James and Shettey, 1982; Sukhatme and Margen, 1982; and Taylor and Keys, 1950). Research in New Guinea has also suggested that humans can adapt to very low protein intakes (Ferro-Luzzi *et al.*, 1975). The question of "adequate" diet thus becomes complex, as the changing standards for FAO requirements reflect.

High variability among individuals and among populations in the rate of nutrient synthesis and metabolism makes it difficult to judge the adequacy of traditional diets simply from an inspection of foods ingested. A more meaningful criterion may be the ability of individuals to maintain function (*e.g.*, growth and development, learning, work performance, reproduction). The relationship of energy intake and work performance is important for developing countries. If dietary restrictions impairs working ability, this has negative implications for economic growth and change. While humans adapt to low energy intake by decreasing requirements, they also do so by slower growth, small body size, and reduced levels of activity (Francois *et al.*, 1983; Keys *et al.*, 1950; Satyanarayana *et al.*, 1977; and Thomas, 1975). The relation of these factors to overall productive capacity is an important consideration in assessing the economic impact of nutrition programmes (Belli, 1971; Correa and Cummins, 1970; Harris and Harris, 1982; and Latham, 1975).

Subsistence and Dietary Change

In the current situations of modernisation and economic development the causes and consequences of dietary change are relevant questions. Traditional diets in the developing world have been influenced by changes either in the system of food production or in the amounts and types of foods available. The impact of modernisation on diet varies widely, from change in only one staple to a complete adoption of a westernised diet. The nutritional consequences of change are accordingly varied, ranging from a net improvement in nutritional balance (with ionization of salt, for example, or parboiling of rice before milling) to increased incidence of diet-related disease and death (Huss-Ashmore and Johnston, 1985).

Causes of Malnutrition

PEM is the most common type of nutritional disease. Among the biocultural factors known to be important in the development of PEM are maternal nutritional status, patterns of breastfeeding and weaning; interactions with infectious disease, and the sociodemographic profile of the household (Huss-Ashmore and Johnston, 1985). These factors are susceptible to change with the impact of modernisation.

Studies in the aetiology of childhood malnutrition suggest a link with the nutritional status of the mother. Taller and better-nourished women have fewer obstetrical complications and lower perinatal mortality (Thomson and Hytten, 1977). Higher survival rates for the offspring of larger mothers are largely attributable to the decreased incidence of low birth weight (less than 2500 g) infants in this group. Low birth weight may be the result not only of overall maternal nutritional status, but also of maternal diet during pregnancy. Delgado *et al*. (1977) have estimated that 13-43% of the infants born to low-SES parents in developing countries weigh less than 2500 g. Such infants have twice the risk of neonatal mortality and are more susceptible to infectious diseases. Dietary supplementation can result in higher birth weights, larger subcutaneous fat deposits, and better temperature regulation for offspring. Increased maternal food variety and vitamin supplementation have also been advocated in developing countries for their beneficial effects on foetal and infant nutrition (Bashir *et al*., 1981; Black and Sanjur, 1980; and Underwood, 1980).

Infant feeding and weaning practices are important factors that have been shown to influence the development of PEM. Marasmus is connected with abrupt, early weaning (in the first year), bottlefeeding, diarrhoea, and withholding of food (McLeren, 1976). Kwashiorkor appears to be related to weaning during the second year onto a high-carbohydrate, low-protein diet. Advocacy of breastfeeding and improved weaning diet are based on their potential to lower the health risk for young children (Chavez, *et al.*, 1975; Frisancho, 1978; and Mata, 1978). Thus both the decline in prevalence of breastfeeding (Hofvander and Pastros-Barvazian, 1978; and Popkin *et al.*, 1982) and factors that influence breastfeeding (Guthrie *et al.*, 1983; and Huffman, 1984) are of interest.

It is widely accepted that the chronic malnutrition ubiquitous in developing countries is rooted in the environments within which at-risk populations live and their children develop. These environments are not only responsible for failing growth in children, they are also responsible for the maintenance of poor nutritional status and for a general lack of catch-up in growth and other indicators (Johnston *et al.*, 1984a; and Scholl *et al.*, 1979).

The identification of specific causal factors responsive for intervention is difficult. Humans and their feeding activities must be viewed in an ecological perspective (Huss-Ashmore and Johnston, 1985), in order to understand factors that cause food systems to break down, resulting in both chronic and acute malnutrition.

Some authors have approached the identification of the causes of malnutrition by analysing specific variables associated with nutritional deficiency, for example, at the level of policy (Behar, 1977) and at the research level (Kanawati and McLaren, 1973; and Lechtig *et al.*, 1975). Other authors have taken a systematic and ecological approach to this issue, emphasising the complexity of the problem (Cravioto, 1970; and Cravioto *et al.*, 1967). Mata's extensive work in Santa Maria Cauque, Guatemala, emphasises the need to examine microenvironmental factors within the home (Mata, 1978).

Social and demographic factors that influence the development of PEM in children include family income, family size, parental education, parenting styles (affection, attention), and other measures of home environment. Below a certain threshold value PEM is most strongly associated with income (Bairagi, 1980). Above this threshold maternal education appears to be the more important factor (Florencio, 1980; Moreno-Black, 1983; and Pellet, 1982). Improved income has more effect on nutritional status with a literate mother (Bairagi, 1980) suggesting that the two have an interactive effect. Other associated variables include number of children in the family, birth order of the malnourished child, presence of intellectual stimulation factors, and occupation of the father (Florencio, 1980; Sheffer, *et al.*, 1981; and Wale and Rodrigues, 1980).

Johnston *et al.* (1980a) applied principal component analysis to a correlation matrix of 38 × 38 environmental and parental-anthropometric variables and extracted seven components : (*a*) Socioeconomic status, (*b*) family demography, (*c*) child morbidity, (*d*) maternal body mass, (*e*) paternal body mass, (*f*) maternal linear size and (*g*) paternal linear size. Component scores calculated were related to body size from birth to 36 months; in addition, the mean scores for each component were compared in children with and without chronic PEM. SES, linear size of the mother, and the linear size of the father were significant components in these analyses. Children with chronic PEM came from poorer homes and had parents who were smaller. The two components summarising parental linear dimensions were interpreted as reflecting the nutritional history of the parents when they themselves were children. The authors concluded that the parents had "recreated" their own childhood environments in their homes. This finding introduces a generational component into the problem of malnutrition.

By using a stepwise discriminant function to test the predictive strength of parental nutritional history, with the contrast being children with and without chronic PEM, five variables provided maximum differentiation of the groups. These were the hip and shoulder breadth of both father and mother, and the personal hygiene score of the father. These variables were sufficient to correctly identify approximately 77% of the children as malnourished or not malnourished. This analysis lent further support to the importance of the environments of the parents when they were children as determinants of malnutrition among their offspring.

Nutrition and Agricultural Development

To improve the nutritional status of disadvantaged populations is one of the basic aims of international development efforts. The success of specific projects such as direct nutritional intervention programmes, like the school feeding programmes, indicate that temporary differences in nutritional status can be achieved (Anderson, 1982; and Berg, 1981). However the ability of such efforts to change health on a sustainable basis is questionable. Furthermore, the nutritional outcomes of such indirect programmes of assistance as development of infrastructure, income generation, or intensification of agricultural inputs are still debated (Berg, 1981; and Pinstrup-Andersen, 1981).

Recently emerged as a topic of anthropological interest is the nutritional consequences of agricultural development and agricultural policy. These policy-related studies are an out-growth of a larger tradition in anthropology that has long been concerned with the outcomes of patterns of food production, consumption and distribution. The shift in emphasis from traditional food systems to those undergoing modernisation is a recognition that processes of economic change may influence nutritional status. The differences in influence for different portions of the population, and the reasons for them, are particularly critical problems (Huss-Ashmore and Johnston, 1985).

The current controversy over the nutritional effects of wage labour and agricultural commercialisation (Fleuret and Fleuret, 1983) is, on one hand, whether the forces of socioeconomic change increase the purchasing power of rural households, thus ensuring security of food supply (Chernichovsky, 1978; and Srinivasan, 1980) or, on the other hand, whether commercial agriculture and labour migration increases the incidence of malnutrition, primarily through changes in patterns of cropping, consumption, and household labour allocation (Dewalt, 1983; Dewey, 1979; and Schofield, 1979). Fleuret and Fleuret (1980) in a review of this controversy conclude that commercial agriculture and attendant socioeconomic change may put at peril the nutritional status of children in participating households. At issue here is the trade-off between (*a*) the perceived benefits that result from improved diets due to increased family incomes, and (*b*) the increased risks to food supply that derive from the abandonment of subsistence agriculture for cash cropping (Eicher and Baker, 1982). Increased risk is atleast partially a consequence of reduced variability, both in crop mix and in overall economic strategy. Many of the indigenous food systems studied have maintained their stability by flexible and varied strategies for food procurement (Colson, 1979; and Dewalt, 1983). Such strategies have acted to even out seasonal and long term fluctuations in food supply. The nutritional success of commercial agriculture for developing countries will depend on its ability to provide access to essential dietary resources during times of economic or ecological crisis (Huss-Ashmore and Johnston, 1985).

While there is still little empirical research on nutritional effects of cash cropping, existing literature indicates that commercial agriculture may interfere with nutritional status through at least four routes (Huss-Ashmore and Johnston, 1985) :

(*a*) It may interfere with consumption patterns in the household. Gross and Underwood (1971), for example, have demonstrated that commercial sisal workers in Brazil required such large caloric intakes that nutritional resources were diverted to them from other household members, particularly children. Calorimetric work from other area support these findings (Eder, 1978; and Taussig, 1978).

(*b*) It may interfere with either quantity or quality of food supply, through reduction of food production. This has been noted by many authors (Adams, 1972; Dewalt and Pelto, 1977; Dewey, 1981; Hanks, 1972; and Picon-Reatigui, 1976).

(*c*) It may interfere with both subsistence production and domestic processes of reproduction, through reallocation of household labour. This process may increase the demands on labour time of women, thus changing cooking habits (Fleuret and Fleuret, 1983; International Centre for Research of Women, 1980; and Lampl *et al.*, 1978). Huss-Ashmore (1982; 1984) has shown that the seasonality of these demands can lead to seasonal problems in nutrition and health for rural women and their children.

(*d*) Further, commercial agriculture may interfere with household acquisition of food by changing control of income, budgeting, and resource distribution. In traditional food systems, adult females often control distribution (if not production) of staple foods, particularly those produced by the household. With a shift to increased cash income, males may increasingly control resource flow. By allocating household resources to purposes other than food acquisition, they may inadvertently reduce quantity or quality of food available to other family members.

Recent empirical studies suggest that some of these problems can be offset by diversification of economic strategies. Fleuret and Fleuret (1983) found that East African households that supplemented either wage labour or commercial agriculture with household food production showed the best nutritional status. Brown and Patridge (Brown and Patridge, 1984; and Patridge *et al.*, 1982) have shown, for a group of resettled farmers in Southeastern Mexico, that best nutritional status is seen in households that also have access to essential economic resources for production, such as irrigation water or outside income.

Nutritional Intervention and Child Development

In view of the importance attached to childhood malnutrition and its implication for later function, it is no wonder that a considerable effort has been devoted by workers in basic and applied fields toward programmes designed to reduce malnutrition and its impact.

Biological anthropologists, as well as people in other related disciplines, have played a number of roles in nutritional intervention. Much of their effort, discussed above, has been in basic research on the correlates of malnutrition that might be altered through specifically designed programmes. Research designed to determine indicators of nutritional status enables effective screening programmes to identify the malnourished (Habicht *et al.*, 1982; and Martorell *et al.*, 1980).

Bioanthropologists, according to Huss-Ashmore and Johnston (1985), also help to evaluate the effectiveness of nutritional intervention programmes. In some instances the interventions are local and specific; in others, the programmes are large in scope and comprehensive in application. Unfortunately, "successful" intervention programmes are all too few, and it is still impossible to develop models that may be applied broadly in the developing world (Underwood, 1983).

Brozek *et al.* (1977) reviewed comparisons of six longitudinal studies on the effects of nutritional supplementation on growth and behavioural development. Supplementation of the mother can increase birth weight, while supplementation of the child will improve growth rate; but "there is probably no true catch-up growth that will bring (children) to accepted norms of their age groups" (Brozek *et al.*, 1977). In all cases, socioeconomic variables also affect growth and may confound the evaluation of the nutritional effect.

Adair and Pollitt (1985) have recently summarised a series of in-depth analyses of the Bacon Chow study, a comprehensive intervention with rural Taiwanese women. Eligible women were followed from before the birth of one child until 15 months following the birth of a second infant, with dietary supplementation from the first birth onward. The study was unique in that a woman could serve as her own control. Adair and Pollitt concluded that, while supplement effects could be seen, there were no clear differences between the first and the second children. As did Brozek *et al.* (1977), they emphasised the difficulties in isolating main effects from the array of endogenous and exogenous variables that interact with the treatment.

Other studies of the impact of nutritional intervention have dealt with improved diets of children (Sellers *et al.*, 1982), and physical growth (Mora, *et al.*, 1981a and b). Each has shown some effects, but all emphasise the complexity of nutritional ecosystems and the problems in identifying a direct effect of the supplement from among other interacting variables.

2

Malnutrition in Kenya

Malnutrition is defined as "a state of impaired functional ability or deficient structural integrity or development brought about by a discrepancy between the supply to the body tissues of essential nutrients and the specific demand for them" (Burton, 1976). This state can clinically be manifested or detected by biochemical, anthropometric or physiological tests (Jelliffe, 1966).

As already outlined elsewhere in the present work, malnutrition is, apart from being ubiquitous in developing countries (Huss-Ashmore and Johnston, 1985), a problem with multiple causation (Cravioto, 1970; Cravioto *et al*., 1967). In Africa, where breastfeeding is widely practised and generally continues for periods of 18-24 months, nutritional disorders are more frequently observed between 18 and 36 months (DeMaeyer, 1976) which suggests that there may be some close association between nutritional disorder prevalence and weaning habits. Cultural and other practices of various groups of people play a considerable role in determining weaning patterns. Among the Hausa women of Nigeria (Osuhor, 1980), for example, -these factors include : religious beliefs, the child's attainment of the traditional age of weaning, the onset of another pregnancy, severe illness or death of the mother, and the husband's unwillingness to observe the traditional abstinence from· sexual intercourse during lactation. In Africa generally, supplementary foods introduced between 5-9 months of age were found to be deficient in energy, essential nutrients, and proteins. Normally, as the case is, the infants are weaned into foods with high carbohydrate content with the result that protein-calorie malnutrition (PCM) occurs with a frequency of 30-50% (Latham, 1979). The main feature of PCM is lack of proper growth usually easily observed from anthropometric measurements.

As in most other African countries, not much data on nutritional status is available on Kenyan populations and even when available, the areas mostly represented are those in and around Machakos district. This is probably because the area is closer to Nairobi, the capital city of Kenya. It could also be because of considerable aridity and inadequate rainfall as a result of which the inhabitants are constantly exposed to various nutritional stresses. Perhaps the earliest study of growth and nutrition in Kenya is that of the Pastoral Masai carried out with comparative data gathered on agricultural Kikuyu (Orr and Gilks, 1931). This work is difficult to evaluate since they have not discussed methods of age determination (Little *et al.*, 1983).

The first nutritional survey of independent Kenya, covering the period 1964-1968, was carried out by the Ministry of Health of the Kenya Government in collaboration with WHO, FAO and UNICEF (Diesfeld and Hecklau, 1978). Other nutritional status surveys have been carried out by the Central Bureau of Statistics (CBS). The first survey conducted by the CBS during the second phase of the National Integrated Sample Survey

Programme (NISSP-IRSII) covered a total of 1400 Kenyan Rural children aged between 1 and 4 years. The second survey had a total of 4000 children from both rural and urban areas aged between 6 and 60 months, whereas the third survey included 4500 children aged between 3 and 60 months (CBS, 1983). These three surveys by the CBS and that of the 1964-1968 period revealed that the most prevalent form of malnutrition in young Kenyan children is PCM whose primary cause is lack of adequate food. In particular, the areas surveyed in the 1964-1968 period showed that 75.8% of the calorie intake was contributed by carbohydrates, 14% by proteins and 10% by fats. Samples in the aforesaid survey, taken in the Central, Nyanza and Kamba regions during the 1965 period revealed that towards the end of the agricultural year, more than 50% of the families consumed less than 80% of the appropriate quantity of foodstuffs (Diesfeld and Hecklau, 1978).

The three surveys of the CBS in 1977, 1979 and 1982 reveal that there has been a small degree of deterioration of about 3 to 4 per cent in the nutritional status between the 1977 survey and the 1982 survey. Of the 40 districts in Kenya, the districts of Kisii, Machakos, Kakamega, Nakuru, Muranga and Siaya exhibit a high proportion of malnourished children. In general, Coast, Nyanza and the Western provinces were noted as areas with the highest levels of nutritional stunting (CBS, 1983).

Studies carried out among the pastoral nomads of North-western Kenya (about 1000 metres above sea level), the Turkana, show that individual nutritional supplies vary from time to time as observed from changes in body composition and weight (Galvin and Little, 1987). The highest losses are recorded between the annual fluctuations of availability of foods and energy intake as in among the Nunoa inhabitants in the Southern Peruvian highlands. The intake is highest immediately after the harvest period (Leonard, 1987). Clearly ecological, cultural and biological factors all focus on man's food intake (Newman, 1977) and the quality of ingested food is reflected in the nutritional status of an individual.

In the surveys carried out by the CBS, their target population over the years has been the young children aged below 5 years. Studies have not really been undertaken to find out as to what extent are school-going children in Kenya exposed to nutritional stress. Although it can be assumed that by and large their nutritional status does not change much from what is observed in the under-five surveys, still more insight is called for to investigate into the effect of biocultural factors affecting growth and development in children of school-going ages. It is known that continued exposure of children to nutritional stresses can cause set-backs in their mental development (Brazier, 1975; Cravioto *et al.*, 1974; Freeman *et al.*, 1980; and Johnston, *et al.*, 1987) and hence performance at school (Morley and Woodland, 1979). With the introduction of school milk programme in all primary educational institutions evaluation of the nutritional status of the school-going children becomes all the more necessary. Such an evaluation will go into explaining as to how much the programme has improved the nutritional status of the school-going children. Besides, investigations carried out among school age children will provide much needed base line data for evaluating various nutritional programmes such as the school milk programme. Also, in the surveys by the CBS, only two anthropometric measurements, weight and height, were used for computation of three nutritional status indices : height for age; weight for age; and weight for height (CBS, 1983). The use by the CBS of height and weight as indicators of nutritional status may have the advantage of being based on easily obtainable measurements but as Frisancho and Tracer (1987) point out, they are ineffective for accurately distinguishing the truly malnourished child from the simply under-weight child. PEM is characterised by a decrease in both fat and muscle tissue. Usually a child suffering from PEM will have a low weight for height, but a tall and normally lean child can also have a low weight for height. Similarly, because obesity is characterised by excess fat, an obese child usually has a high weight for height; but a muscular and large-framed child can also have a high weight for height. This implies that excess weight does not necessarily mean excess fat, or being underweight is not necessarily associated with PEM.

For this reason, assessment of nutritional status based only on weight and height, especially when the degree of under- or over-nutrition is moderate, is bound to be ineffective in distinguishing the truly wasted (*i.e.*, low fat and muscle) from the normally low-weight child and the truly obese from the normally heavy child. Therefore, because of the lack of an appropriate anthropometric standard, evaluations of malnutrition are either grossly overestimated or underestimated (Dibly, *et al.*, 1985; Keller *et al.*, 1983; Monteiro, 1985; and Trowbridge, 1979). A basic biologic principle is that the organism's response to malnutrition follows a hierarchical sequence in which the nutritionally labile tissues, such as fat and muscle are depleted first and, as malnutrition continues (in the case of children), growth in stature is retarded, which in turn may lead to stunting (Frisancho and Tracer, 1987).

Objectives of the Present Study

This brief review of various studies on the nutritional status carried out in Kenya reveal that there is a critical need to evaluate the physical growth and nutritional status of children in Kenya against their biocultural environment. In the present study, the results of which are reported in the following pages, an attempt has been made to evaluate the physical growth and nutritional status of school age children belonging to Kisii district of Nyanza province in Western Kenya. For this, the below-mentioned objectives were set out to provide the necessary guidelines for the conduct of the survey and presentation of the results :

(*a*) To observe the pattern of physical growth of Kisii children of school-going ages in terms of a number of anthropometric variables.

(*b*) To evaluate the extent of malnutrition among these children through the use of nutritional anthropometry.

(*c*) To figure out the frequency of various common nutritional deficiency signs among the school-going Kisii children.

(*d*) To observe various variables of their micro-environment–food habits, sanitary facilities, access to clean drinking water, housing conditions, and health care facilities as probable determining factors of malnutrition.

(*e*) To compare the physical growth pattern and nutritional status of Kisii children with those of school-going age children in other parts of Kenya, and from elsewhere in and outside Africa.

(*f*) To explore the possible reasons for the malnutrition among Kisii children especially in terms of their biocultural background.

3

Kisii District–Land and People

Kenya is located on the eastern part of Africa. With Uganda to the West and Tanzania to the South, the three countries together comprise East Africa. The country extends from 4°S latitude to 4° N latitude, 33°E longitude to 42°E longitude, an area of about 564,162 square kilometres (CBS, n.d) (Fig. 3.1). To the north, Kenya borders with Ethiopia and Sudan, to the east are Somalia and the Indian ocean with the palm fringed shores. The country is bisected longitudinally by the Great Rift Valley coming down from Ethiopia into Tanzania and beyond. Roughly one third of the country lies on the west and the remaining two thirds on the east of the Rift Valley. The Rift, which in many places is many kilometres across and in some areas has very steep sides as high as 600 metres, opens like a funnel at its northern extremities into the Red sea and the Gulf of Aden. For about a thousand years, it has been a route for southward population movement, with groups in some cases spreading out into the surrounding plateau areas as well (Ottenberg and Ottenberg, 1960). The famous palaeoanthropological sites of hominid

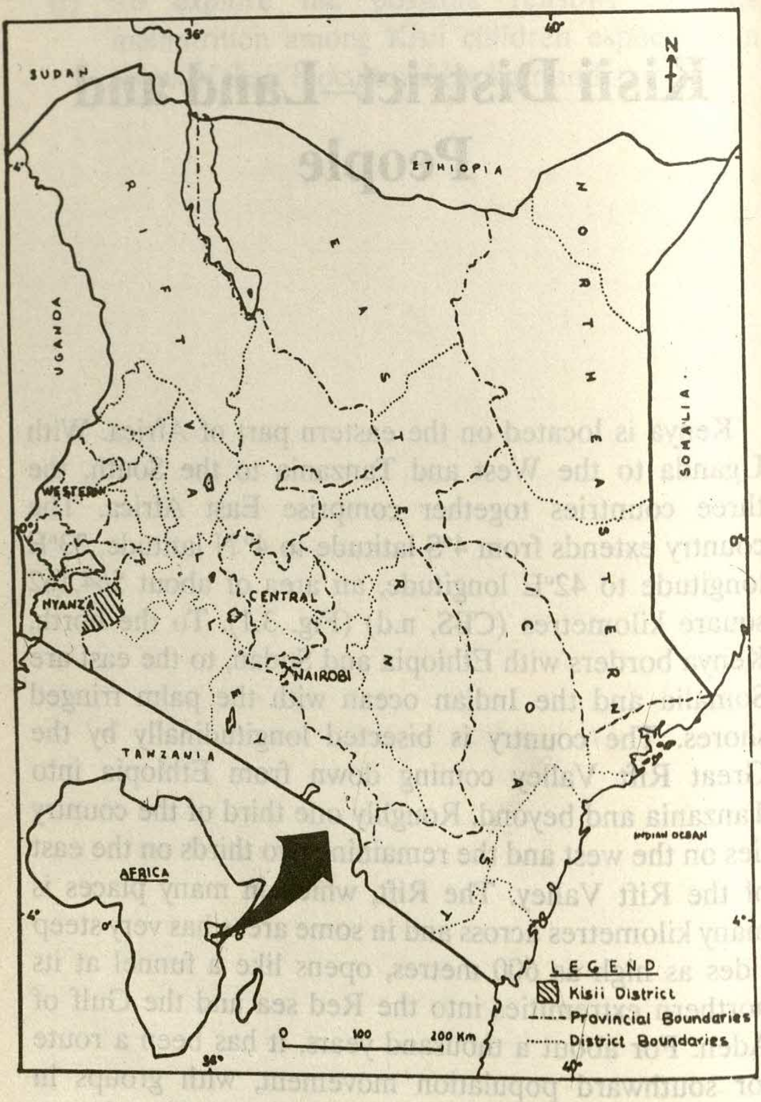

Fig. 3.1 : Map of Kenya showing location of Kisii District.

evolution : the Omo Valley, Lake Turkana area, Fort Ṭernani, and the Olduvaigorge, are some of the areas of anthropological interest in the valley.

Ecological Zones of Kenya

Kenya can be divided into six major ecological zones based on the vegetation present in each zone (Diesfeld and Hecklau, 1978). These zones are :

1. Ecological zone 1 which consists of moorland and grassland or barren land at high altitude above the forest line. This zone is found only on Mount Kenya and in the Aberdare Range.
2. Ecological zone 2 is made up of forests and derived grasslands and bushlands, with or without natural glades. The potential for this area is for forestry or intensive agriculture.
3. Ecological zone 3 along with areas at lower altitudes in ecological zone 2 provide a living area for the peasant societies in areas with good rainfall and therefore suitable for agriculture ranging between 1,000 m-1,500 m above sea level. It also includes areas at the coastal lowland.
4. Ecological zone 4 consists of land with marginal agricultural potential, carrying a natural vegetation, dry forms of woodland and savanna, or derived semi-evergreen or deciduous bushland. The more open parts of this zone have a high density of wildlife.
5. Ecological zone 5 represents areas very locally suited to agriculture. The woody vegetation is mostly of shrubby habit. Perennial grasses dominate.

6. Ecological zone 6 consists of range lands of low potential. The vegetation here consists of dwarf shrub grassland, or a very dry form of bushed grassland. Here productivity is confined largely to unreliable seasonal flushes and grazing systems are based on nomadism. The populations of both wild and domestic stock are restricted severely by the environment.

Ecological zones 5 and 6 together extends over about four-fifths of the Kenyan land surface area (Diesfeld and Hecklau, 1978).

The plains and the varied forms of dry Savanna areas present a combination of low rainfall normally less than 508 mm annually, a long dry season, poor predictability in any one given year, and periodic droughts. These are severe limiting factors to productivity in the region and the human and livestock carrying capacity of the ecosystem is maximised by continual movements of the settlements and herds in quest of water and good pasture (Little and Morren, 1976). These areas are mostly occupied by the nomadic tribes.

This provides a sharp contrast to the fertile well-watered Kenyan highland region which is densely inhabited by small-scale farmers and also in some places by large-scale farmers. Numerous cultivated plants, cereals, tubers, vegetables, fruits, coffee and tea are found here. In the Rift valley area one sees across, over the Savanna, salt lakes and extinct volcanoes, large farms providing for the fast growing urban populations with maize, wheat, milk, and meat.

Perhaps the most important factor that determines the population distribution is the agrarian carrying capacity. In over two-thirds of surface area of Kenya the agrarian carrying capacity is low, and so is the population density. Kenya's relief is of great importance for the climate of the country, particularly as regards the amount and distribution of rainfall and temperature. The climatic factors in turn condition the ecological picture and the agrarian capacity, which influences the density and distribution of peasant and herding communities (Diesfeld and Hecklau, 1978). The climate is typically tropical with long rains coming in from March to June and the short rains from November to early December. Areas with more than 762 mm rainfall annually are fully utilisable for agricultural purposes. There is, however, always a lurking danger of drought induced crop failures, resulting in famine over large parts of Kenya and as a consequence the population is frequently exposed to inadequate nutritional supplies. By constructing grain storage facilities, the government is trying to bring about a more equitable distribution of its food produce so as to alleviate the situation as a result of drought induced famines. Perhaps a more important approach would be to persuade the farmers to also improve the on-farm storage facilities so as to reduce the total loses due to pests and other causes.

Temperature at various places in Kenya and indeed in East Africa is roughly guided by altitude. There are, however, marked local differences in the rate of change of temperature with altitude. In places about 1800 metres above sea level a mean temperature of 13.5°C in the coldest month is observed. The coastal areas, most areas in Northeastern province, the Eastern province, areas around Lake Turkana and Lake Victoria have annual maximum mean temperature of over 30°C. These areas, except for the region around Lake Victoria with mean annual minimum temperature of 18°C, have temperatures of 18°C or more. The rest of the country has a mean annual maximum temperature of less than 26°C and a mean annual minimum temperature of less than 14°C.

Kisii district (Fig. 3.2) is situated in the western part of Kenya within the approximate bound of 0°25" south–0°58' South and 34°37' East – 35°5' East. The district covers 2196 square kilometres, about 0.4% of Kenya. Altitudes range from about 1219 metres above sea level in the west to 1829 metres in the east with a few areas of the central highlands exceeding 2133 metres above sea level (Epp *et al.*, 1984).

The soils of Kisii district are mainly of volcanic origin. In general terms the district is quite fertile and produces a variety of crops and animal products. Coffee and tea are grown in almost all parts of the district; in areas of Wanjare, Machoge and West Kitutu (Fig. 3.2) bananas are widely grown, sugarcane and groundnuts are mainly found in South Mogirango, groundnuts are grown in some areas in West Kitutu. Maize, the staple food of the Abagusii (the Kisii people) is grown all over the district, in some parts twice a year as may be necessitated by demand. Other crops that need mention include–finger millet, sweet potatoes (grown mainly as drought crops), and green vegetables. Vegetables are primarily grown for home consumption. Milk is widely used but is in areas of Borabu and perhaps East Kitutu where meaningful yields are realised.

Rainfall in the district varies from less than 1600 mm per year in the south-west corner to more than 2000 mm per year in the central highlands. Rainfall shows an increase with rise in altitude. Four seasons, as in most other parts of Kenya, can be distinguished. The main

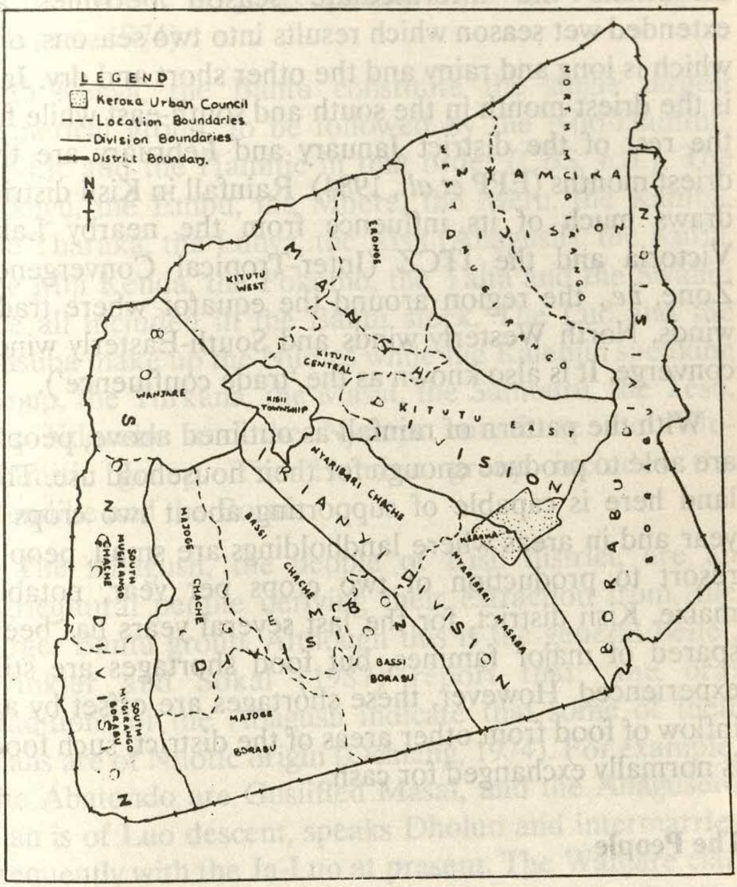

Fig. 3.2 : Sketch Map of Kisii District.

rainy season lasts from March to May with some little rains coming again from September to November. The dry spell lasts from December to February. At higher elevations the intermediate season becomes an extended wet season which results into two seasons, one which is long and rainy and the other short and dry. July is the driest month in the south and south-east while for the rest of the district January and February are the driest months (EPP *et al.*, 1984). Rainfall in Kisii district draws much of its influence from the nearby Lake Victoria and the ITCZ (Inter-Tropical Convergence Zone, *i.e.*, the region around the equator where trade winds, North Westerly winds and South-Easterly winds converge. It is also known as the 'trade confluence').

With the pattern of rainfall as outlined above, people are able to produce enough for their household use. The land here is capable of supporting about two crops a year and in areas where landholdings are small, people resort to production of two crops per year, notably maize. Kisii district, for the last several years has been spared of major famines, but food shortages are still experienced. However, these shortages are offset by an inflow of food from other areas of the district; such food is normally exchanged for cash.

The People

The East African highlands have been areas of constant migration sometimes accompanied by warfare, one group often trying to displace the other (Ottenberg and Ottenberg, 1960). The present occupiers might have only come in much later. It is probable that the Bantu speaking people were the first to arrive probably through the corridors that lie between Lakes

Tanganyika and Meweru. They may have pushed further down the original inhabitants, the Bushmen-Hottentot group. The Bantu speaking people were then followed by the Nilotic language people from the Nile region (Shorter, 1974).

In Kenya, the Bantu constitute the single largest numerical group, to be followed by the Nilo-Hamitic, Nilotic and the Hamitic in that order (CBS, n.d.). The Kikuyu, the Embu, the Mbere, the Meru, the Kamba, the Tharaka, the Luhya, the Kisii (Abagusii), the Kuria, the Miji Kenda, the Pokomo, the Taita and the Swahili are all included in the Bantu stock. The Luo and the Basuba make up the Nilotes while the Kalenjin speaking group, the Turkana, the Masai, the Samburu, the Teso, the Ndorobo and the Njemps constitute the Nilo-Hamitic group. The Hamitic group includes the Rendille and the Boran.

The Abagusii, the people of Kisii district, are an agricultural people deriving their extraction from, the larger Bantu group. Although this is the general belief, Winkler and Sokal (1987) report that "the oral traditions of the Abagusii indicate that some of their clans are of Nilotic origin (Ochieng, 1974). For example, the Abatondo are Gusiified Masai, and the Abagusero clan is of Luo descent, speaks Dholuo and intermarries frequently with the Ja-Luo at present. The Wanjare clan is also of Luo descent. Furthermore, according to Ochieng (1974), the relations of the Abagusii with their Nilohamitic neighbours, the Kipsigis and the Masai, have been biologically more or less insignificant, the relations with the Ja-Luo, however, have never been restricted to cultural or trading relations". The genetic distance of the Abagusii and the various other groups, that Ochieng (1974) names, still remains undone.

Traditional cultural practices of the Abagusii were aimed at keeping the integrity of the group. Children were prepared in a variety of ways and in doing so the child or youth was not only introduced to the knowledge and skills appropriate for an adult of his or her sex but was also taught deeper values within and loyalty to the community. Within the community there was a shared responsibility of the child's upbringing. At various stages of life the child was placed in the hands of relatives and not necessarily only with its own immediate parents. In doing so, the child developed greater self-assurance and established a net-work of personal links so important in adult life. The emergence of western type of education brought in, initially, by the missionaries and later adopted by the government has nowadays changed the whole scenario. The upbringing of the child is no longer the community's responsibility but rather is of the parents at home and the teachers at school. They all have a shared responsibility of moulding a child into the demands of the present times – a child with a nationalistic outlook.

The child was introduced to wider responsibility within the society as a whole through progressive formal instructions and rituals. Ceremonies aimed at testing the courage, endurance, submission, and ability to withstand pain, symbolised the changed personality of the young individual emerging into an adult. Through such ceremonies the young adult was prepared for the demands that the society would make upon him or her. Although these ceremonies are still performed and people do still attach cultural sentiments to them the tests they used to administer to the initiate have lately assumed less importance. It is viewed by the people as merely a fulfilment of the cultural practices and it is this factor that has kept their place in the present social set-up.

The family inherited property and status along patrilineal lines. This still remains the common practice. Marriage among the Abagusii, as in most other sub-Saharan communities, is a form of contractual quid pro quo between two lineages, and not a direct commitment between husband and wife. Marriages were usually arranged by older members of the clan. Residence of the married couple was and still remains patrilocal. Premarital virginity was usually held in higl esteem. Polygamy served the family by providing larger progeny and, since it depended on economic factors, was one of the most important expressions of affluence.

Unlike practices outside sub-Saharan Africa, a wife does not bring wealth with her into the marriage in the form of dowry, rather she is exchanged for wealth, termed as bride-price given to her parents (Frank and McNicoll, 1987). Usually it was in the form of livestock. The bride-price given to the bride's parents established the legal paternity of children that the bride would bear, as well as guaranteeing the man's responsibility for her welfare. In return, the acceptance of the brideprice signified a pledge that she would be a good wife and bear children for her husband; should she fail in her marital obligations then they would return all or part of the bridewealth (Ottenberg and Ottenberg, 1960). Bridewealth nowadays remains a mere token and its conversion largely into money does not cause anxiety. Young men find it increasingly difficult to comply with the requirements of this custom. Bridewealth today is easily circumvented in initial stages of a union, although it may be an eventual feature of most unions.

Traditional religion today hardly enjoys the role it had in the olden days. Traditional beliefs and practices have apparently disappeared as a result of the influence from western style religions. Among the Abagusii, and indeed in many other tribes in Kenya, religion was based on the belief in the supernatural power of ancestors and certain forces associated with nature. Thus, when a mother would wake up in the morning she would face the sun and pray, "Rioba nderere nainche inkorerere" (literally asking the sky to care for all that is within her province and in turn she would reciprocate). It was not the sky she communicated with but rather the sky acting as a mediator she communicated with the unseen supreme being. Uplands were usually associated with "Okonyiba" (rain making ceremonies). "Omonyibi", the rainmaker, was thought of as having powers to communicate with the unseen God. Thus in times of droughts, people would come out to these high grounds to perform special dances (known locally as "ribina") and certain rites believed to cause rain.

Traditional life imposed restrictions on various foodstuffs to be made available to different age and sex categories. These limitations, or taboos, were associated with certain happenings which were thought possibly to occur as a result of defiling the taboos. Among the Abagusii, women were not allowed to take neither chicken nor eggs. It was considered ominous for women to eat eggs. Children were forbidden from taking liver lest they become stubborn. These and other factors could affect the availability of proteins to one group more than the other. The distribution of foods was governed by strict social norms and everyone was obliged to comply, deviance being met with severe sanctions. These beliefs are still prevalent among some of the older people who constitute a small and least assertive fraction of the population. The items of food which were taboo in the past, are freely available to all. Inspite of the restrictions imposed on various foods, the Abagusii had good knowledge of their habitat and an awareness of when and where to obtain a particular food.

Demographic Factors

Kenya's rate of population increase is quite high. The population grew from about 10,943,000 people in 1969 to about 15,327,000 people in 1979, an average annual increase of about ½ million people (CBS, n.d). UN (1985) population projections indicate that as of 1987 there were 22,391,000 people in Kenya and this figure is projected to increase to 24,363,000 people by 1989 and will double by the turn of the century. The Crude Birth Rate (CBR, the total number of children born, say, in 1 year per 1000 people in the population) of Kenya between 1980-1985 was 55.1 while the Crude Death Rate (CDR, the total number of deaths, say, in 1 year per 1000 people in the population) was 14.0 for the same period giving a natural population increase of 4.1% (1979 population census of Kenya obtained a CBR of 52 per thousand (CBS, n.d.)). Whereas the CDR has dropped down from 18.1 in the 1970-1975 period to 14.0 in the 1980-1985 period the CBR has only marginally changed (from 56.7 in the 1970-1975 period down to 55.1 in the 1980-1985 period). With these changes in mind, it is not hard to note that the total population change in percentage has been increasing gradually. The population change was 3.87% in the 1970-1975 period and stood at 4.12% in the 1980-1985 period. The total fertility stands close to eight births per woman (Frank and McNicoll, 1987). Since the population growth, in accordance with Malthus theory, is geometrical and food production arithmetical there is a clear indication that much of Kenya's population will in future get hardly enough to match the Recommended Daily Allowances (RDA). Already malnutrition is ranked 5th among the major causes of child deaths in Kenya. A higher male mortality rate is recorded in nearly all districts than that recorded for females (Table 3.1.). Infant mortality in mid-1970's has been found to be 104 (sexes combined) per thousand live births (CBS, n.d.).

TABLE 3.1: *Infant and Child Mortality in the First 5 Years of Life in Mid-1970's*

	No. dying per 1000 live births		
	Total	Male	Female
Kenya	156	161	151
Nyanza Province	220	226	214
Kisii District	134	138	129
Kisumu District	246	253	239
Siaya District	259	270	248
South Nyanza District	266	270	263

Source : CBS, n.d.

The population density in Kenya rose from 29 people/sq. km in 1980 to 35 people/sq. km. in 1985. But the picture is not as good as it may appear. The population of Kenya is very unevenly distributed. Taking Nairobi, Central Province (excluding Nyandarua district), Nyanza Province, Western Province, and Mombasa, Embu, Meru, Kericho, Nakuru, Nandi, Trans-Nzoia and Uasin Gishu Districts, it appears that more than two-thirds of the population of Kenya is living on less than one-tenth of the land area. Nor does this proportionate concentration appear in any way diminishing : the aggregate populations of these densely inhabited areas in 1969 comprised 66.3% of the total population compared with 67.4% in 1979.

Three main regions of population concentrations may be defined :

(*i*) the Lake Victoria Basin, comprising Nyanza and Western provinces;

(*ii*) the East and West Rift highlands, comprising Nairobi, Central Province, Rift Valley Province (but excluding Turkana, Samburu, Baringo, Laikipia, West Pokot and parts of Kajiado and Narok) and Eastern province (but excluding Isiolo and Marsabit); and

(*iii*) the Coastal Belt, comprising Mombasa, the coastal areas of Kwale, Kilifi and parts of Taita-Taveta.

These major population concentrations separate vast areas of low population densities in northern, eastern and southern Kenya (CBS, n.d.). The 1969 census indicated that there were 103 persons per square kilometre on the arable land. In the 1979 census the figure had gone up to 147 persons per square kilometre in nearly all of Kenya's arable land and by 1985 there were about 188 persons per square kilometre of arable land (CBS, n.d). The population pressure on arable land is forcing many young people to move to urban areas in search of better ways to earn a living. Initially the rural-urban migration was to Nairobi and Mombasa but with the emergence of many urban centres in different provinces of Kenya, rural-urban migration streams have become broad phased than before. This process has generated a number of difficulties for the urban residents–shortage of housing, overcrowded education

Table 3.2 : *Area, Population and Density of Kisii District 1969 and 1979*

	Area		Population 1969		Population 1979		Density	
	Sq. km.	%	No	%	No	%	1969	1979
Kenya	564,162	100.0	10,942,705	100.0	15,327,061	100.0	19	27
Nyanza Province	12,525	2.2	2,122,045	19.4	2,643,956	17.3	168	211
Kisii District	2,196	0.4	675,041	6.2	869,512	5.7	304	395

Source : CBS (n.d.).

and health institutions, the deterioration of other facilities (CBS, n.d), and especially the emergence of fast growing slums. In 1962 population densities in Kisii district ranged from 250 to 400 persons per square kilometre. In the 1969 census the Kisii highland showed a core area with densities well in excess of 400 persons per square kilometre in such sublocations as Mwamanwa, Mwamosioma, Bogichora and Bosamaro East. Elsewhere away from Kisii district, densities declined westwards towards the lake shore areas. The population of Kisii district as per the 1979 census was 869,512 people Table 3.2. This gives a population density of 395 persons per square kilometre, an increase of about 30% over that the 1969 population density figure. In 1979 the core density area of Kisii highlands had become more distinct. Average rural densities ranged from about 500 to well over 1000 persons per square kilometre. In the more congested areas of Central Kitutu the sublocations of Mwamosioma and Mwabondusi had rural densities well in excess of 1000 persons per square kilometre. Similarly, the sublocations adjacent to Kisii Township had densities well in excess of 1000 persons per square kilometre. Elsewhere in Kisii, densities were well above 400 persons per square kilometre (CBS, n.d.). As a result of high population density the land holdings per person have considerably reduced in recent years. This fragmentation of land and the making of hedges have further reduced the available land for food production. At 8.7 children per woman, a substantial proportion of the members of the community are young and actively growing. They require adequate nutritional supplies which are hard to come by in some areas. The high population density, high birth rate coupled with cultural and other factors may affect the production and distribution of various food crops both within and between families.

4

Material and Methods

The present study was carried out in the rural area of the Keroka Urban Council of Kisii District on 324 school-going children aged between 5 through 14 years in the months of March and April, 1988. There were 164 boys and 160 girls whose anthropometric measurements and clinical observations were taken. Table 4.1 gives the sample distribution according to sex and age.

TABLE 4.1 : *Distribution of Sexes According to Age of the Study Group*

Age	Male	Female	Total
5	17	12	29
6	16	20	36
7	14	23	37
8	13	23	36
9	18	14	32
10	16	20	36
11	19	19	38
12	20	12	32
13	12	13	25
14	19	4	23
Total	164	160	324

In order to get the above sample, subjects were visited at their schools. In all, 4 schools, randomly sampled, were visited. These schools are Kierira Primary School, Kegogi Primary School, Keroka Diocese of Kisii Primary School and the Keroka Urban Council Nursery School.

A number of subjects were later on followed in their respective homes so that more information regarding their household and personal habits including feeding habits could be obtained and other ecological factors evaluated. This survey was carried out on 116 families. For the purpose of this study, a family was defined as a group of people consisting of a husband, a wife and atleast one offspring. In addition to the above factors looked into during the home visits demographic factors were also enquired into.

Information was obtained on the following three main items :

I. Ecological background including information on the educational background of both the parents, the weaning practices, demographic factors and the types and frequencies of foods eaten by the study population.

II. Anthropometric measurements.

III. Clinical observations.

I. Ecological Survey

Information collected during this survey included the features of microenvironment (that is, the environment around the homestead including type of the house, source of water and its subsequent treatment, general cleanliness of the children, the state of utensils used for cooking and the general illumination and ventilation in the house). By the state of utensils used for cooking it is not meant looking into the quality of utensils used, rather it was an evaluation of whether the utensils were kept clean and properly stored. For illumination and ventilation, the type and the size of the windows used in the house and the general brightness in the house were important considerations. Information on the socio-economic background and the types of foods consumed was also collected. During this survey the ages of children given at the school were verified from their parents. The ages reported by the parents and recorded in the school registers are quite reliable as both depend upon the system of birth registration by the state and at the churches.

II. Anthropometric Measurements

Seven anthropometric measurements were taken on each child. The definitions landmarks and instruments used were according to Weiner and Lourie (1969). While in the measurements of various body dimensions the conventional instruments, like anthropometer, weighing machine, and skinfold calipers were used, for head circumference and mid upper arm circumference the Ross Laboratories Insert-tape (Ryan and Martinez, 1987) utilized.

The following measurements were recorded on each of the 324 school-going children :

1. *Weight*

Weighing was done with the subject wearing minimum clothing on a regularly calibrated spring loaded weighing machine. The subject was asked to stand on the weighing machine and the weight reading recorded to the nearest 0.5 kg.

Instrument : Portable spring-loaded weighing machine.

2. *Height*

The subject was asked to stand on a horizontal platform with his heels together, stretching upward to the fullest extent, aided by a gentle traction on the mastoid processes by an assistant. The subject's back was made as near straight as possible by being asked to round or relax the shoulders and to manipulate the posture accordingly. After making sure that the marked Frankfort Plane is horizontal, the horizontal arm of the anthropometer was brought down to the subject's head and, while keeping the instrument vertical, the reading was taken to the nearest 0.1 cm.

Instrument : Anthropometer.

3. *Sitting Height*

The subjects were measured with the back stretched up straight as they sat on a table-top with their feet hanging down unsupported over the edge. The back of the knees should be directly above the edge of the table. Gentle traction was applied under the chin and the subject asked to relax the muscles of the thighs and buttocks. The head was held in the Frankfort horizontal plane, and the anthropometer vertically held in contact with the back of the sacral and interscapular regions. The reading was recorded to the nearest 0.1 cm.

Instrument : Anthropometer.

4. *Head Circumference*

With the subject seated, the maximum circumference of the head was measured with a non-stretchable plastic tape (Ross Laboratories Insert-Tape). The tape was passed above (but not including) the brow ridges, above the ears, and around the occipital prominence at the back of the head, that is from glabella to opisthocranion back to glabella. The tape was pulled snug and kept in one horizontal plane. Head circumference was recorded to the nearest 0.1 cm.

Instrument : Ross Laboratories Insert-Tape.

5. *Mid Upper Arm Circumference*

The measurement was taken with the Ross Laboratories Insert-Tape with the left arm hanging relaxed just away from the side of the subject. The circumference was taken horizontally at the marked level, that is midway between the top of the acromion (acromiale) and the olecranon process (the elbow). This measurement was taken to the nearest 0.1 cm.

Instrument : Ross Laboratories Insert-Tape.

6. *Chest Circumference*

This measurement was taken at the marked union of the 3rd and 4th sternabrae, at right angles to the axis of the body, at the end of a normal expiration. The reading was recorded to the nearest 0.1 cm.

Instrument : Steel Tape.

7. *Triceps Skinfold*

The skinfold is picked up between the thumb and fore-finger and the caliper jaws applied at exactly the level marked. The measurement is read 2 seconds after the full pressure of the caliper jaws is applied to the skinfold; if longer interval is allowed the jaws may 'creep' and the reading be inaccurate. The tension of the spring of the caliper should be checked frequently to minimise errors due to differential pressure on the skinfold.

Over triceps : The skinfold was picked up at the back of the arm about one centimetre above the level marked on the skin for the upper arm circumference and directly in line with the point of the elbow or olecranon process. The reading is recorded to the nearest 0.1 cm.
Instrument : Una's skinfold calliper.

Incidence of Malnutrition

In the third world countries malnutrition is widespread. Changing world economic conditions are gradually pushing one group of people to one extreme while another group is being pushed to the other. While nutritional supplies for one of these groups does not meet the body demands the other is getting more than enough supplies leading, for both groups, to various nutritional complications. Malnutrition (or more specifically undernutrition) has a big impact on the normal development as observed from individuals with regard to changes in their anthropometric measurements. To measure the extent of such changes is an important part of nutritional surveys. ·Various approaches are in use for evaluating the growth and nutritional status of children and adults (Frisancho and Tracer, 1987; Gomez *et al*., 1956; Waterlow *et al*., 1977; Jelliffe, 1966; Kanawati and McLaren, 1970; among others). The usual approach is to use the 50th percentile of a given standard with the various corresponding measurements.

In the present work, the authors have adopted for use three methods : weight-deficit (Gomez classification); height-deficit (Waterlow classification); and triceps skinfold classification.

(*i*) *Gomez Classification :* The classification takes into consideration that a person who is undernourished will have a weight deficit. Using Stuart and Stevenson (1963) Standards, four categories of nutritional status can derived :

More than 90% median weight for age : Normal

76%-90% median weight for age : Grade I malnutrition (marginal).

61%-75% median weight for age : Grade II malnutrition (moderate).

Less than 60% median weight for age : Grade III malnutrition (severe).

(*ii*) *Waterlow Classification :* This classification is for those people who exhibit a height deficit. These people do not have the height expected for their age. Four categories of nutritional status can be derived using Stuart and Stevenson (1963) Standards :

More than 95% expected height for age : Normal

91%-95% expected height for age : Grade I malnutrition.

85%-90% expected height for age : Grade II malnutrition.

Less than 85% expected height for age : Grade III malnutrition.

(*iii*) *Using the Triceps Skinfold Measurement* : This is based on the classification given in Jelliffe (1966), according to whom four categories of nutritional status can be derived :

91%-110% median TSF* at the age : Normal

81%-90% median TSF at the age : Grade I malnutrition.

61%-80% median TSF at the age : Grade II malnutrition.

Less than 60% median TSF at the age : Grade III malnutrition.

III. Clinical Observations

Clinical observations are based on examination of changes which are related to inadequate nutrition, and which can be seen or felt in superficial epithelial tissues such as the skin, the eyes, the hair and the buccal mucosa, or in organs near the surface of the body like parotids and thyroid glands.

The clinical changes related to nutrition are present in high frequencies in areas where malnutrition is widespread. Observations were taken according to Jelliffe (1966) and Latham (1979).

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* TSF = Triceps Skinfold.

A. Hair

The normal hair of an African child is curly, usually dark black and coarse in texture. It reflects off light shone to it. In Kwashiorkor, the hair becomes silkier and looses its curls as the texture changes. It lacks the lustre and may change the colour to brown or reddish brown. In persons suffering from Kwashiorkor, a small tuft of hair can easily be pulled out with moderate force and without pain. This is marked on the temporal region. The hair may become thin and sparsely distributed on the scalp.

B. Eyes

1. Bitot's spots

These are dry, greyish, silvery or chalky-white foamy plaques, often triangular or irregularly circular in shape, which are seen usually on both eyes. In Africans they are often surrounded by a brown-pigmented area. These lesions are associated with Vitamin A deficiency in young children. Bitot's spots may accompany the generalized Conjuctival Xerosis.

2. Conjuctival Xerosis

This condition is seen as a drying (Xerosis), thickening, pigmentation and lack of lustre and transparency of the bulbar conjunctiva of the exposed part of the eyeball. Often the conjunctiva is wrinkled and is not wetted by tears. The process of drying and thickening is due to keratinization affecting the cells of the conjuctival epithelium. This condition is a sign of Vitamin A deficiency and may lead to keratomalacia and blindness if not treated.

3. Pallor of the Conjunctiva of the Lower Eyelid

The examiner checks the lower lid of the eye from the inside. In case of children suffering from anaemia it appears paler than normal. The examiner can compare the redness of the lower eyelids with those of a normal person.

4. Vascularization of the Cornea

This represents an invasion of all quadrants or whole of the cornea by fine capillary blood vessels. It is believed to be associated with riboflavin deficiency.

C. Lips

1. Cheilosis

In cheilosis cracks, which may be either red and sore or dry and healing, occur on both lips. The centre of the lower lip is most usually affected. Cheilosis frequently occurs in conjunction with angular stomatitis. Deficiency of riboflavin may be the cause.

2. Angular Stomatitis

This develops as fissures or cracks radiating from the angles or corners of the mouth. The fissures may be shallow or deep, confined to a small area of the angles of the mouth or extending into the buccal cavity and a few millimetres onto the skin outside. Milder lesions are discerned more easily with the mouth half open. The sign should be taken as positive only if both angles of the mouth are involved. This condition is especially associated with riboflavin deficiency. Niacin and pyridoxine deficiency may also be involved.

D. Tongue

1. Oedema of the Tongue

This can be detected by the indentations made by pressure of teeth along the edges of the tongue. The papillae are usually prominent. This condition is associated with deficiency of riboflavin and niacin.

2. Magenta Tongue

The tongue is purplish red in colour, numerous morphological changes may co-exist.

3. Atrophic Papillae

The filiform papillae are absent giving the tongue an extremely smooth appearance. The distribution may be central or marginal. It may be painful. This condition may be due to a lack of niacin.

4. Scarlet and Raw Tongue (Glossitis)

The tongue is bright red in colour, usually of normal size or slightly atrophic, denuded due to desquamation and very painful. It is usually due to niacin deficiency that this condition appears.

E. Teeth and Gums

1. Mottled Enamel

The teeth are mottled with white and brownish patches, with or without erosion or filing of the enamel, usually best seen in the upper incisors.

2. *Dental Caries*

The presence of decayed, missing or filled teeth (DMF) is often used to record the amount of caries present in a community. Teeth may, however, be missing due to some other reasons like accidents and removal because of local customs as is among the Luo community and the Kalenjin community of Kenya. In children in most tropical areas with inadequate dental services, only the presence of decayed teeth with cavities can be recorded. The method of examination is usually by inspection alone.

The prevalence of caries in children is suggested by the percentage of those with one or more teeth decayed or filled (DF). Caries in both deciduous and permanent teeth is more related to local effects of the foods consumed, especially to the dietary content and frequency of ingestion of sugar, over-milled flour and other highly refined carbohydrate foods. Malnutrition in pregnant women plays a part in the aetiology of caries in the first dentition of children.

3. *Spongy and Bleeding Gums*

Purplish or red spongy swelling of the interdental papillae and/or the gum margins, which usually bleed easily on slight pressure. This sign, which suggests absence of Vitamin C, is absent even in severe cases of lack of Vitamin C in children until the teeth have erupted.

F: Skin

1. *Oedema*

Usually first apparent over the ankles and feet, it may extend to other areas of the extremities. In early stages, it can be detected by firm pressure for three seconds with one digit on the lower portion of the medial surface of the tibia. The sign is taken as positive if there is a visible and palpable pit that persists after the pressure is removed. It is recorded only if present bilaterally. Oedema is normally a sign of Kwashiorkor.

2. *Pellagrous Dermatosis*

Typical pellagrous skin lesions are symmetrical, clearly demarcated, hyperpigmented areas with or without exfoliation. The lesions are common in parts of the body exposed to sunlight, including the cheeks and the forearm; when they appear around the neck the condition is called "Casal's necklace". In acute cases, the skin is red, slightly swollen and may show vesiculation, exudation and cracking. The condition is due to niacin deficiency.

3. *Flaky-paint Dermatosis*

The skin resembles a paved walk or the sun-baked and cracked bed of a dried up mud swamp. There are islands of fairly normal skin, each surrounded by a shallow crack. The edges may be scaly or desquamating. It can occur anywhere, but characteristically on the buttocks and the back of the thighs. Protein deficiency may play a part in its causation; dirt and alternate exposure to dryness and moisture under hot conditions may also be alternative causes.

4. *Xerosis*

This is represented by generalized dryness with branny desquamation. Factors to be considered when interpreting this and other skin signs are environmental, such as dirt, lack of washing, a dry, hot windy climate, and the habitual use of oil on the body. The condition is thought to be mainly due to Vitamin A deficiency.

5. *Follicular Hyperkeratosis*

Two clinical types are recognised :

(*a*) *Type 1* : in which the lesion consists of hyperkeratosis surrounding the mouths of hair follicles and forming plaques that resemble spines. It is readily detected by the spiky feeling it gives when the palm is passed over an area of affected skin. Its characteristic distribution is frequently confined to the buttocks, thighs and especially the extensor aspects of the legs and arms, particularly the elbows and knees. The surrounding skin is dry and lacks the usual amount of moisture and oiliness.

(*b*) *Type 2* : in which the lesions have a similar appearance, but the mouths of the hair follicles contain blood or pigment. The intervening skin usually is dry. The condition is mostly seen in adults. The distribution is usually over the abdomen and the extensor aspects of the thighs.

Type one is usually associated with Vitamin A deficiency while type two is possibly due to Vitamin C deficiency.

G. *Glands*

1. *Thyroid Gland Enlargement (Goitre)*

This is visibly or pulpably enlarged. The enlargement may be diffuse or nodular. Inspection and palpation while the subjects swallows may be helpful in diagnosis. In classification, three grades are recognised :

(*a*) *Grade 1* : Persons with palpable goitres. The thyroid is probably enlarged four to five times, although not visible with the head in normal position. Most cases will be readily visible with the head thrown back and the neck fully extended. Palpation is carried out by the examiner sitted or standing facing the subject and placing his thumbs gently on either side of the thyroid area.

(*b*) *Grade 2* : Persons with visible goitres. Goitres in this category can be recognised easily with the head in a normal position; they are however smaller than goitres in grade 3.

(*c*) *Grade 3* : Persons with very large goitres. Goitres in this category can be recognised from a distance. They are grossly disfiguring. Iodine deficiency causes the enlargement of the thyroid.

2. *Parotid Enlargement*

This sign is positive if there is a chronic, visible, non-inflamatory, bilateral swelling of the parotids. The glands are firm, non-tender and painless with the overlying skin unchanged. It is mostly seen in school children and adults. Parotid enlargement is usually graded according to size. If the swelling is marked the lobules of the ears are hidden when the subject is viewed from the front.

H. Skeleton

1. Knock-Knees and Bow Legs

Once a child with rickets begins to stand, walk and become active, he develops new deformities due to the soft, weak character of the bones. The commonest of these is bow-legs, and, less frequently knock-knees. Knock-knees and bow-legs occur in older children and may at times be an healed case.

2. *Epiphyseal Enlargement*

Enlargement of the epiphyseal ends of long bones, particularly affecting the radius and ulna at the level of the wrist, and the tibia and fibula at the level of the ankle. In the assessment of this sign, allowance must be made for the degree of subcutaneous fat present. In wasted persons the ends of the long bones appear unusually prominent.

The nutritional deficiency signs were broadly classified as indicating Vitamin A deficiency, Vitamin B deficiency, Vitamin C deficiency and Vitamin D deficiency. In addition, the frequency of dental caries was also determined in the various age groups.

Statistical Analysis

The following statistical formulae were used for analysing the present work.

1. *Arithmetic Mean* ($\overline{X}$)

Arithmetic mean gives the average value of the whole range of data given. This is given by the formula :

$$\overline{X} = \frac{\Sigma X}{n}$$

where $\overline{X}$ = Arithmetic mean.
n = the total number of variables.
ΣX = Sum of all the recorded variables.

2. *Standard Deviation. (s.d.)*

It gives the degree of dispersion of recorded data around the mean.

$$\text{s.d.} = \sqrt{\frac{\Sigma(\bar{X} - X)^2}{n-1}}$$

where s.d = Standard deviation.
$\overline{X}$-X = Deviation of the variables from the mean.
n = Total number of variables (to minimize errors in view of the small samples taken one is subtracted from n).

3. *Standard Error (S.E.)*

It enables the measurement of the magnitude of sampling error. Two types of standard errors can be calculated :

(*a*) Standard error of mean, SEM, is calculated by using the following formula :

$$\text{S.E.M.} = \frac{\text{s.d.}}{\sqrt{n-1}}$$

where SEM = Standard error of mean.
s.d. = Standard deviation.
n = Size of sample.

(*b*) Standard error of standard deviation, SESD, is calculated by using the formula :

$$\text{S.E.S.D.} = \frac{\text{s.d.}}{\sqrt{2n-1}}$$

where SESD = Standard error of Standard deviation.

s.d. = Standard deviation.

n = Size of sample.

4. *Observed Range*

The observed range is given by the difference between the largest and smallest values in a set of given data.

5. *Coefficient of Variation (C.V.)*

This gives the variation or dispersion around the mean as a percentage of that mean, that is :

$$\text{C.V.} = \frac{\text{s.d.}}{\overline{X}} \times 100$$

where C.V. = Coefficient of variation.

s.d. = Standard deviation.

$\overline{X}$ = Arithmetic mean.

6. *t-Test*

The *t*-test gives the difference between two means, $\overline{X}_1$ and $\overline{X}_2$, of two independent samples of size n_1 and n_2 and s.d. of S_1 and S_2. It enables us to test the hypothesis that the samples come from the same normal population, that is $\overline{X}_1 - \overline{X}_2 = 0$

This test is given by the formula :

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s} \times \sqrt{\frac{n_1 n_2}{n_1 + n_2}}$$

and

$$s = \sqrt{\frac{s_1^2 n_1 + s_2^2 n_2}{n_1 + n_2 - 2}}$$

Where $\bar{X}_1$ = mean of first sample with s.d. = s_1
$\bar{X}_2$ = mean of second sample with s.d. = s_2
n_1 = size of the first sample
n_2 = size of the second sample
s = combined s.d.

7. *Correlation Coefficient* (*r*)

A correlation coefficient is an index that measures the strength of a relationship between two variables in a given set of data. The possible values of the correlation coefficients range from +1 to −1 for complete positive and negative correlation. Complete correlation describes a situation where all the readings lie on a straight line having either positive or negative slope. Correlation coefficient near zero represents situations where there is no particular tendency for two sets of data to cover linearly.

The correlation coefficient, r, is given by the following formula :

$$r = \frac{\Sigma\,[(X-\bar{X})\,(Y-\bar{Y})]}{\sqrt{[(X-\bar{X})^2\,\Sigma\,(\bar{Y}-\bar{y})^2]}}$$

Where r = correlation coefficient

X and Y represent two sets of data with respective means $\overline{X}$ and $\overline{Y}$

8. *Regression Equation*

A regression equation between two variables describes how one variable, say Y, varies with unit change in the other, say X.

The simple regression equation is given by

$$Y = a + bX,$$

where X and Y are variables, and a and b are constants.

$$\text{a (intercept)} = \frac{N \Sigma XY - (\Sigma X)(\Sigma Y)}{N \Sigma X^2 - (\Sigma X)^2}$$

$$\text{b (regression coefficient)} = \frac{(\Sigma Y)(\Sigma X^2) - (\Sigma X)(\Sigma XY)}{N \Sigma X^2 - (\Sigma X)^2}$$

5

Observations

Microenvironment

The microenvironment more often than not plays a role in the causation of disease which in turn has an effect on the nutritional status of an individual. A poorly maintained microenvironment can be a breeding ground for malaria germ–carrying mosquitoes, for house flies, for diarrhoea and dysentery–causing germs and many other related diseases.

In the present study, a number of such factors as may be considered part of the microenvironment have been looked into. These factors included : the source and quality of drinking water; the quality of the house (floors, roofs and walls); rubbish disposal; ventilation; cleanliness of the children and the utensils used. In all, 116 families responded to various questions put to them in this regard. Table 5.1 (a) shows those who responded to questions on the source and treatment of water, and Table 5.1 (b) shows the investigators' own judgement on rubbish disposal, ventilation of the house, cleanliness of the children and the state of cooking utensils.

Table 5.1 (a) : ***Predominant Source of Water and its Treatment***

Source	No	%	Treatment	No	%
Well	8	6.9	1. Those who boiled water	23	19.8
Spring	40	34.5			
River	40	34.5	2. Those who do not boil water	93	80.2
Piped	28	24.1			
Total	116	100.0		116	100.0

Table 5.1 (b) : ***Investigator's Judgement on Rubbish Disposal, Ventilation, Cleanliness of the Children and State of Cooking Utensils***

Rating	Rubbish disposal		Ventilation and illumination		Cleanliness of children		State of cooking utensils	
	No	%	No	%	No	%	No	%
Very good	15	12.9	10	8.6	3	2.6	1	0.9
Satisfactory	62	53.5	58	50.0	92	79.3	85	73.2
Poor	39	33.6	48	41.4	21	18.1	30	25.9
Total	116	100.0	116	100.0	116	100.0	116	100.0

1. Source and Treatment of Water (Table 5.1a)

Of 116 mothers who responded to this question, 6.9% used well water, 34.5% used spring water, 34.5% used river water, and 24.1% used piped water. Of those who used spring and river water, 2.5% used other sources also, generally Rain water. Only 19.8% boiled water before used for drinking. The rest (80.2%) who did not boil water before use mainly included those who had access to piped or spring water.

2. *Type of House*

Among the types of houses, 85.3% had houses made of earth, 8.7% had semipermanent houses and 6% had permanent houses. In 81.9% cases, the floors were not cemented; only 18.1% houses had cemented floors. 35.3% of the respondents had grass thatched houses while 64.7% had iron-sheet roofs. Earth is the predominant source of wall making material : 85.4% of the houses had mud walls; 6.0% houses had walls of stone; and in the remaining 8.6% houses, walls were made of mud but were plastered.

3. The other remaining factors are summarised in Table 5.1(b). From the table it may be seen that 12.9% of the houses had very good disposal habits. 53.5% of the houses had satisfactory and 33.6% had poor rubbish disposal habits. Thus about two-thirds of the households scored satisfactory or above so far as their rubbish disposal habits were concerned. In most of those cases judged as being below satisfactory, rubbish was found strewn all over the homestead. 8.6% had well ventilated and illuminated houses, 50% had satisfactorily ventilated and illuminated houses while 41.4% had poorly ventilated and illuminated houses.

Child cleanliness was generally found satisfactory. 2.6% had a very good score, 79.3% of the cases scored satisfactory while 18.1% had a poor score.

In assessing the condition of the cooking utensils, the quality of the material used was disregarded. The cleanliness of the utensils was a more important consideration in the present study. Thus, 0.9% scored very good, 73.2% cases were satisfactory and 25.9% scored poorly.

Occupation, Educational Level, Land-holdings and Land Use

1. Occupation and Educational Level

In the present study, the authors have grouped various jobs into four basic categories : the professionals; farmers; skilled labourers; and unskilled labourers. Professionals include teachers and doctors, skilled labourers include drivers and factory workers, while the unskilled labourers include people like the watchmen and newspaper vendors. 24.1% of the homes visited were headed by a person who was in a professional job. Farming was the main job among 61.6% of the people, 8.9% were skilled labourers while the unskilled labourers accounted for 5.4% of the homes visited.

In terms of their educational qualifications, differences were observed in the levels of education attained in the two sexes as seen from Table 5.2. Among women the highest proportion of 46.96% never had any formal education, 23.50% terminated their studies

Table 5.2 : *Educational Levels Attained by the Parents*

Class Attained	Sex			
	Male		Female	
	No	%	No	%
No Education	36	31.3	54	46.96
Standard 7	13	11.3	27	23.50
Form II	16	13.9	8	6.93
Form IV	24	20.8	20	17.39
Form VI	4	3.5	0	0
College	22	19.2	6	5.22
Total	115	100.0	115	100.00

before or in the 7th standard, 6.95% completed form II standard, 17.39 attained the form IV standard and only 5.22% ever reached college level. The situation in the case of men is rather different : 31.3% never went to school, 11.3% completed upto standard 7 level, 13.9% were of the form II level, 20.8% reached the Form IV level and a total of 22.7% attained post-secondary education; 3.5% having attained form VI level; and 19.2% college level education.

2. *Land Use and Land-holdings*

Kenya Rangeland Ecological Monitoring Unit (KREMU; Epp *et al.*, 1984) conducted a survey on various types of uses the land in Kisii district was put to. The various types of land use identified are given in Table 5.3.

The most dominant land use was that of grazing and fallow land which occupied 33% of the total area (Table 5.3). Next in decreasing order were fields of young maize (19%), bare ground (16%), hedges (8%), woodland (8%), old maize (3%), and tea (3%). These eight land uses jointly cover 93% of the total land area in the district. The remaining 7% comprised land allocated to coffee, sugar cane, pyrethrum, bananas, sweet potatoes, finger millet, buildings, marshes, markets, schools, water bodies, and other unidentified types. Included in these unidentified types of land use are napier grass, cabbage, cassava, and tobacco.

The area in which the present study was carried out according to the KREMU report, had about 33% land left fallow or for grazing. The other types of land uses identified in decreasing order were fields of young maize (30%), bare ground (17-20%), hedges (10%), old

Table 5.3 : *Means and S.E. of land-use characteristic in Kisii District*

Land-use Type	District mean (n = 89)	S.E.
Crazing/fallow	32.33%	1.03
Young maize	18.92%	0.49
Bare ground	15.88%	0.33
Hedges	8.43%	0.14
Woodland	8.21%	0.22
Old maize	3.32%	0.13
Roads, tracks and foot paths	3.06%	0.03
Tea	2.92%	0.11
Structures	1.85%	0.03
Sugar cane	1.16%	0.17
Other unidentified* land uses	0.94%	0.02
Schools and market centres	0.56%	0.01
Coffee	0.52%	0.01
Marshes	0.45%	0.03
Bananas	0.44%	0.02
Sweet potatoes	0.38%	< 0.02
Pyrethrum	0.30%	< 0.01
Water bodies	0.12%	< 0.01
Finger millet	0.02%	< 0.01
Thatch roof houses	21.57/km^2	1.25
Grain stores	16.47/km^2	0.83
Metal roof houses	8.82/km^2	0.61
Latrines	2.66/km^2	0.04
Average field size	0.18 ha	0.04

*Unidentified types include napier grass, cabbage, cassava, tobacco, fish ponds and passion fruit trees.

Source : KREMU, Epp. *et al.*, 1984.

maize (8-11%), woodlands (8%), coffee (1%), and banana (0.5%). The average field size was ½ acre.

The study carried out by the present investigators reveals that the average landholdings per person is about 4.16 acres with a s.d. of 1.48 acres. Of this land area, 75.6% is used for food production, that is an average of 3.18 acres, with a s.d. of 1.21 acres. The area used for food production ranges from ½ acre to 7 acres. The remaining 24.4% of the land was used mainly for cash crop production. The cash crop grown in this area was mainly tea.

Types and Frequencies of Foods Eaten

Food in Kisii district, in comparison to most other districts in Kenya, may be described as abundant. However, these foods are generally available only during certain seasons of the year.

The Kisii people are accustomed to two main meals a day, lunch and dinner. Breakfast is taken early in the morning before people go out for their daily activities. As it may be seen from Table 5.4, mid-morning and evening meals are not popular. The main foods consumed are given in Table 5.5. A bulk of the breakfast meal (50%) consists of cereal products, mainly maize meal prepared into gruel, or beverages (48.3%), mainly tea. 8.6% of the families use starchy roots and starchy fruits during mid-morning and 6.0% during evening times. These foods include sweet potatoes, English potatoes, and bananas.

Eighty-seven per cent of the families use cereals at lunch time while 96.6% use them at dinner time. People who use vegetables at lunch time are 69.8% and those who use them at dinner time are 61.2%. Among the vegetables, cabbage is commonly consumed. This vegetable is available almost throughout the year.

Families which use animal products during lunch time and dinner time constitute 25% and 42% respectively.

Table 5.4 : *Frequencies of Foods Eaten*

	Breakfast		Mid-morning		Lunch		Evening		Dinner	
Type of Food	N	%	N	%	N	%	N	%	N	%
Cereals	58	50.0	--	--	102	87.0	--	--	112	96.6
Starchy roots and starchy fruits	11	9.5	10	8.6	16	13.8	7	6.0	4	3.5
Pulses and oilseeds	--	--	--	--	36	31.0	--	--	21	18.1
Condiments and spices	--	--	--	--	1	0.9	--	--	--	--
Mineral salts (common salt)	5	4.3	6	5.2	109	94.0	2	1.7	110	94.8
Beverages	56	48.3	--	--	--	--	5	4.3	--	--
Animal products (non fats)	--	--	--	--	29	25.0	--	--	49	42.2
Fruits and vegetables	2	1.7	1	0.9	81	69.8	1	0.9	71	61.2
Sugars	87	75.0	--	--	--	--	6	5.2	--	--
Fats and oils	3	2.6	2	1.7	96	82.8	--	--	100	86.2

Among pulses and oilseeds, beans are widely used (31.0% at lunch time and 18.1% at dinner time). The major foods for this community are mainly carbohydratic in nature. A number of them use vegetables during the main meals of the day. Proteinous foods are used in a limited manner.

TABLE 5.5. *Types of Foods Eaten* *

Cereals	Maize meal (porridge, ugali); Maize boiled; Millet (0.9%); Rice (1.7%)
Starchy roots and fruits	Sweet potatoes; Bananas; English potatoes.
Pulses and oilseeds	Beans.
Condiments and spices	Curry (0.9%).
Mineral salts	Common salt (Iodized).
Beverages	Tea; Cocoa (0.9%).
Animal products (Non-fats)	Meat; Milk; Eggs (0.9%); Fish (0.9%).
Other fruits and vegetables	Green leaves; Citrus (0.9%); Tomatoes (0.9%); Pineapples (0.9%).
Sugars	Refined Sugar (white); Syrups and jams (0.9%).
Fats and oils	Vegetable oils; Margarine.

*Where the number of families who use a particular item is low, the percentage has been given in brackets.

Feeding Habits, Weaning Habits, Disease and Health Facilities

1. Feeding Habits

Of the mothers visited, 81.1% breastfed their children only while 18.9% used both breastfeeding and bottlefeeding methods. No cases of bottlefeeding alone were encountered. 71.1% of the mothers who breastfed their children did not give any supplementary foods, 22.2% gave cow's milk to the young, 5.6% gave porridge and 1.1% gave a combination of both milk and porridge. 52.4% of those mothers who use both breast- and bottlefeeding methods gave cow's milk, 23.8% gave tinned milk (dry milk powder), and 9.5% gave a combination of cow's- and tinned-milk to the young ones as supplementary foods. 14.3% of mothers did not give satisfactory answers regarding the supplementary foods they gave to their children.

2. *Weaning Habits*

71.5% of the mothers breastfed their children for a period longer than one year while 27.88% women breastfed their children for a period upto one year and 0.96% for a period of six months or less. 37.5% of the mothers weaned their children abruptly, 55.8% did so gradually, and 6.7% did not report on the methods they followed when weaning their children (Table 5.6).

TABLE 5.6 : *Time and Type of Weaning*

Type of weaning	More than 1 year	Upto 1 year	Upto 6 months	Total
Abrupt	21	18	0	39
Gradual	46	11	1	58
Not reported	7	0	0	7
Total	74	29	1	104

Ugali, vegetables and milk were used respectively by 70.19% and 63.4% and 36.54% of the mothers as the first weaning foods. All of those who reported the use of vegetables, used them along with 'ugali'. 7.69% use other types of carbohydrates, such as potatoes and bananas, as their first weaning foods. 43.3% reported using porridge as a weaning food.

The age at which weaning starts to take place ranges from 2 months to 8 months. The average starting age is about 5.65 months (s.d. = 1.07 months).

All mothers reported the use of ugali after weaning. 96.8% used vegetables, 35.1% used proteinous foods and 13.8% reported the use of porridge as foods after weaning. 12.8% reported the use of other types of carbohydrate foods (bananas and potatoes) other than those represented above.

3. *Disease and Health Facilities (Table 5.7)*

Of the 95 mothers who responded to questions on health facilities and disease occurrence, 73.7% affirmed that their children (age less than 5 years) had no diarrhoea in the recent past (*i.e.*, did not have diarrhoea within the last two months of the investigation), and 26.3% gave an affirmative response. Twenty per cent of those who affirmed that their children (less than 5 years) had diarrhoea recently said that the affected children had diarrhoea within 5 days of the investigator's visit, 44% within the last 3 weeks, 24% within the last 2 months, and 12% could not recollect when the child had diarrhoea last. 56.84% of the families had children (age less than 5 years) who suffered from diarrhoeal infections in the past more than two months earlier to the investigator's visit. 36.84% reported that their children had not suffered from such infections, and 6.3%

TABLE 5.7 : *Incidence of Diarrhoea and Hospital Attendance*

Response	Recent*		Past**		Visited hospital	
	No	%	No	%	No	%
Yes	25	26.3	54	56.84	49	51.6
No	70	73.7	35	36.84	40	42.1
No report	0	0	6	6.30	6	6.3

* Recent : means those who had diarrhoea within the last two months.

** Past : means those who had diarrhoea more than two months earlier.

did not respond as to whether their children (age less than 5 years) did or did not suffer from diarrhoeal infections.

All respondents interviewed said that they took their children to the Keroka Health Centre for various health complications. The mean distance between a home and the health centre is 3.9 km (s.d. = 1.7 km). The nearest mother interviewed in the present study lived within ½ km. from the health centre while the farthest stays 7 km away. However, it was found that only 51.6% of the children with health problems were ever taken actually to the health centre, 42.1% of the children were not taken unless serious, and 6.3% did not give any definite answer to the question of whether the children were taken for treatment to the health centre.

Anthropometric Measurements

1. *Weight* (Table 5.8, Fig. 5.1a)

Age changes in weight give a general idea of the gross body growth. However, these changes are less informative because body weight represents an accumulated effect of various tissues in the body, each tissue contributing its own share. Weight in itself is a highly variable parameter because it is easily affected by environmental factors. A change in body weight may be the result of changes in the health of an individual, changes in dietary supplies or even changes in one's physical activities.

In the present study, a steady increase in weight is observed from 5 years to 14 years for both boys and girls (Table 5.8, Fig. 5.1a). Between 5 years and 9-9½ years boys are heavier than girls, and after 10 years the trend

TABLE 5.8 : *Weight (kg)*

Age group (yrs.)	Sex	No	Mean	SEM	SD	SESD	CV	Range
5	M	17	16.47	0.51	2.11	0.36	12.81	14.0-21.5
	F	12	15.62	0.38	1.33	0.27	8.53	13.0-18.0
6	M	16	19.09	0.60	2.38	0.42	12.48	15.0-25.0
	F	20	18.65	0.55	2.45	0.39	13.11	15.0-23.5
7	M	14	20.89	0.75	2.81	0.53	13.45	13.0-24.0
	F	23	19.65	0.46	2.22	0.33	11.31	15.0-24.0
8	M	13	23.54	0.97	3.50	0.69	14.86	18.0-28.5
	F	23	22.80	0.63	3.00	0.44	13.17	17.0-30.0
9	M	18	25.64	0.64	2.71	0.45	10.55	21.0-31.5
	F	14	23.75	0.97	3.62	0.68	15.22	16.5-30.0
10	M	16	26.59	1.22	4.88	0.86	18.34	19.5-38.5
	F	20	28.90	0.79	3.53	0.56	12.23	23.5-35.0
11	M	19	32.03	1.40	6.10	1.00	19.05	24.0-48.0
	F	19	28.68	0.77	3.35	0.54	11.67	25.0-35.0
12	M	20	32.10	0.88	3.92	0.62	12.20	24.0-43.0
	F	12	34.25	2.46	8.54	1.74	24.92	23.0-57.0
13	M	12	37.12	1.49	5.16	1.05	13.94	29.5-47.0
	F	13	40.38	1.40	5.06	0.99	12.54	28.0-48.0
14	M	19	39.53	1.07	4.64	0.75	11.75	29.0-47.0
	F	4	42.25	1.03	2.06	0.73	4.88	40.0-44.0

is for girls to generally maintain a higher trajectory than that for boys. The mean weight for boys and girls at 5 years is 16.47 kg and 15.62 kg respectively and at 14 years boys have a mean weight of 39.53 kg, which is 2.72 kg less than the weight of girls at the same age. The total gain from 5 to 14 years is 23.06 kg (58.3%) for boys and 26.63 kg (63.0%) for girls. The C.V. values for boys range between 10.55% and 19.05% while those for girls range between 4.88% and 24.95%. The highest C.V. value for boys is observed at 11 years while that for girls is seen at 12 years of age.

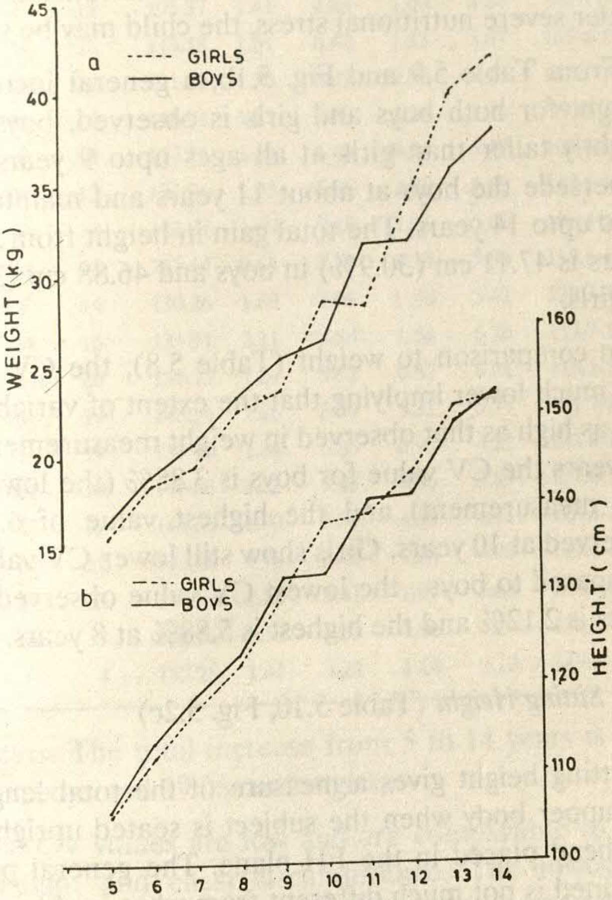

Fig. 5.1 : Distance curves for weight (kg) and height (cm) of Kisii children

2. *Height* (Table 5.9, Fig. 5.1b)

Height, or the total body length, apart from nutritional and other environmental factors, is influenced by hereditary factors. An offspring of tall parents is likely to be tall in normal circumstances but under severe nutritional stress, the child may be stunted.

From Table 5.9 and Fig. 5.1b, a general increase in height for both boys and girls is observed, boys being slightly taller than girls at all ages upto 9 years. Girls supersede the boys at about 11 years and maintain the lead upto 14 years. The total gain in height from 5 to 14 years is 47.11 cm (30.9%) in boys and 46.88 cm (30.7%) in girls.

In comparison to weight (Table 5.8), the CV values are much lower implying that the extent of variability is not as high as that observed in weight measurements. At 12 years the CV value for boys is 3.85% (the lowest for this measurement) and the highest value of 6.7% is observed at 10 years. Girls show still lower CV values as compared to boys : the lowest CV value observed at 14 years is 2.12% and the highest is 5.88% at 8 years.

3. *Sitting Height* (Table 5.10, Fig. 5.2c)

Sitting height gives a measure of the total length of the upper body when the subject is seated upright and the head placed in the FH plane. The general picture obtained is not much different from what is observed in other body measurements in the present study (except the triceps skinfold and head circumference).

Boys lead girls by an average of about 0.47 cm from 5 years upto 9 years. From then on girls take the lead upto

TABLE 5.9 : *Height (cm)*

Age group (yrs.)	Sex	No	Mean	SEM	SD	SESD	CV	Range
5	M	17	105.45	1.45	6.00	1.03	5.69	97.2-122.2
	F	12	105.37	1.41	4.88	1.00	4.64	94.7-114.7
6	M	16	113.18	1.61	6.42	1.13	5.67	105.4-125.1
	F	20	111.72	1.36	6.09	0.96	5.45	102.1-125.3
7	M	14	118.91	1.81	6.78	1.28	5.70	99.4-125.5
	F	23	117.21	1.34	6.41	0.94	5.47	106.6-130.0
8	M	13	123.04	1.93	6.96	1.36	5.66	112.6-133.7
	F	23	122.07	1.50	7.18	1.06	5.88	107.4-136.4
9	M	18	131.64	0.64	2.71	1.30	5.94	118.6-153.5
	F	14	130.26	1.89	7.06	1 .33	5.42	120.3-143.6
10	M	16	131.91	2.21	8.84	1.56	6.70	117.7-149.2
	F	20	137.75	1.24	5.52	0.87	4.01	126.1-147.2
11	M	19	140.34	1.86	8.09	1.31	5.77	121.7-160.0
	F	19	138.60	1.34	5.85	0.95	4.22	131.0-149.9
12	M	20	140.88	1.21	5.43	0.86	3.85	127.6-147.1
	F	12	143.36	1.70	5.89	1.20	4.11	128.4-150.1
13	M	12	149.28	1.76	6.09	1.24	4.08	139.6-159.4
	F	13	150.69	1.52	5.47	1.07	3.63	140.5-157.2
14	M	19	152.56	1.50	6.55	1.06	4.29	136.3-162.0
	F	4	152.25	1.61	3.22	1.14	2.12	149.6-156.8

14 years. The total increase from 5 to 14 years is 16.53 cm for boys and 19.06 cm for girls.

The CV values are low and are comparable to those for height and chest circumference. The lowest and highest CV values for boys are 3.8% at 9 years and 6.0% at 14 years respectively while the corresponding values for girls are 3.54% at 14 years and 5.35% at 7 years.

4. *Head Circumference* (Table 5.11, Fig. 5.2a)

The head circumference measurement gives a general idea of what growth changes take place in the head during an individual's development. The measurements made in the present study show little variability.

Once again there are sex differences observed in various age groups, some of them significant ($p < 0.05$, Table 5.15). Infact, apart from the triceps skinfold measurement (Table 5.14, Fig. 5.3b) where girls are ahead of boys throughout the study period, the head circumference measurements in the present study show that throughout the growth period boys are ahead of girls by an average of 1.25 cm.

TABLE 5.10 : *Sitting Height (cm)*

Age group (yrs.)	Sex	No	Mean	SEM	SD	SESD	CV	Range
5	M	17	56.85	0.61	2.50	0.43	4.39	52.2-63.1
	F	12	56.46	0.75	2.61	0.53	4.63	51.3-61.0
6	M	16	60.37	0.64	2.55	0.45	4.23	56.1-65.3
	F	20	59.92	0.52	2.32	0.37	3.88	56.1-63.8
7	M	14	61.61	0.83	3.11	0.59	5.05	52.4-65.7
	F	23	61.02	0.68	3.26	0.48	5.35	56.4-67.3
8	M	13	63.99	0.96	3.46	0.68	5.41	56.9-69.2
	F	23	63.05	0.64	3.08	0.45	4.89	56.7-68.8
9	M	18	65.21	0.58	2.48	0.41	3.80	60.2-71.5
	F	14	65.21	0.86	3.22	0.61	4.94	57.0-70.4
10	M	16	65.86	0.86	3.45	0.61	5.67	59.5-72.5
	F	20	68.36	0.58	2.58	0.41	3.77	63.2-71.9
11	M	19	69.92	0.81	3.52	0.57	5.04	64.1-77.4
	F	19	69.35	0.66	2.89	0.47	4.17	63.4-75.6
12	M	20	68.86	0.65	2.89	0.46	4.20	63.1-74.2
	F	12	70.43	0.85	2.96	0.60	4.20	64.0-74.7
13	M	12	73.54	1.00	3.46	0.71	4.71	69.6-79.5
	F	13	74.18	0.98	3.54	0.70	4.78	63.6-77.4
14	M	19	73.38	1.01	4.40	0.72	6.00	64.1-80.3
	F	4	75.52	1.34	2.67	0.94	3.54	71.6-77.6

Table 5.11 : *Head Circumference (cm)*

Age group (yrs.)	Sex	No	Mean	SEM	SD	SESD	CV	Range
5	M	17	52.26	0.35	1.44	0.25	2.75	50.2-56.6
	F	12	50.53	0.38	1.32	0.27	2.61	48.2-53.1
6	M	16	52.09	0.41	1.62	0.29	3.61	48.7-55.5
	F	20	51.26	0.20	1.00	0.16	1.96	49.5-53.8
7	M	14	52.39	0.35	1.29	0.24	2.47	49.8-54.6
	F	23	51.13	0.23	1.09	0.16	2.14	48.7-52.7
8	M	13	52.53	0.34	1.22	0.24	2.32	50.8-54.3
	F	23	51.44	0.27	1.29	0.19	2.51	48.6-53.3
9	M	18	53.22	0.32	1.35	0.22	2.54	51.0-55.6
	F	14	51.58	0.24	0.90	0.17	1.74	49.7-50.8
10	M	16	53.18	0.56	2.24	0.40	4.22	50.3-57.0
	F	20	52.36	0.27	1.22	0.19	2.34	50.1-54.3
11	M	19	53.59	0.30	1.30	0.21	2.43	50.4-55.5
	F	19	52.37	0.22	0.96	0.16	1.83	51.1-54.5
12	M	20	53.44	0.28	1.26	0.20	2.35	51.6-55.5
	F	12	52.58	0.46	1.60	0.33	3.04	49.6-54.6
13	M	12	54.23	0.44	1.52	0.31	2.81	52.6-58.1
	F	13	52.95	0.34	1.22	0.24	2.31	50.6-54.9
14	M	19	54.15	0.30	1.33	0.22	2.46	51.1-56.4
	F	4	52.35	1.18	2.36	0.83	4.50	50.1-55.5

The highest observed measure for boys is 54.23 cm at 13 years and the lowest is 52.09 cm at 6 years. For girls the highest value for head circumference is 52.95 cm at 13 years and the lowest 50.53 cm at 5 years. The highest CV value is 4.5% at 14 years and the lowest value 1.74% at 9 years for girls while the corresponding values for boys are 4.22% at 10 years and 2.32% at 8 years.

5. *Upper Arm Circumference (UAC)* (Table 5.12, Fig. 5.2b)

The upper arm circumference taken midway between

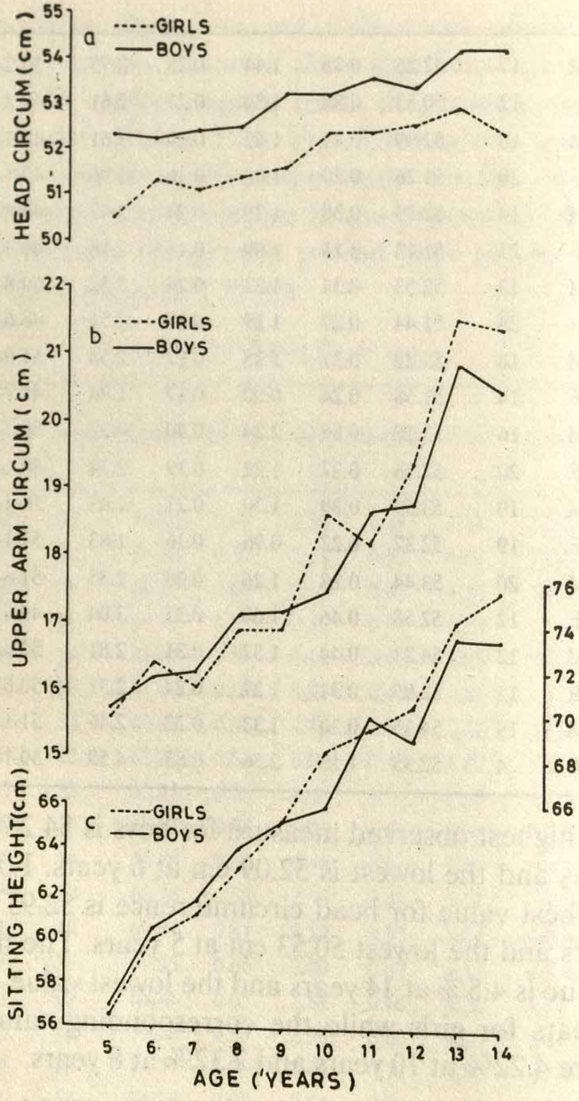

Fig. 5.2 : Distance curves for head circumference (cm) upper arm circumference (cm) and sitting height (cm) of Kisii children.

the acromion process and the elbow is an integrated measure for the skeletal, the muscular, and the subcutaneous tissue components. This measurement is closely, though not exactly, associated with changes in the subcutaneous tissues much because the tissue easily changes under varying circumstances.

There is a general increase in the upper arm circumference from 5 to 14 years (Table 5.12; Fig. 5.2b). Girls have the lowest value of 15.58 cm at 5 years and

TABLE 5.12 : *Mid Upper Arm Circumference (cm.)*

Age group (yrs.)	Sex	No	Mean	SEM	SD	SESD	CV	Range
5	M	17	15.76	0.25	1.03	0.18	6.56	13.5-18.0
	F	12	15.58	0.28	0.99	0.20	6.34	13.9-17.6
6	M	16	16.19	0.24	0.95	0.17	5.87	14.9-18.2
	F	20	16.44	0.24	1.06	0.17	6.42	14.5-18.6
7	M	14	16.31	0.20	0.76	0.14	4.63	14.8-17.6
	F	23	16.08	0.21	0.99	0.15	6.16	14.3-18.1
8	M	13	17.14	0.31	1.13	0.22	6.59	15.5-19.1
	F	23	16.93	0.29	1.41	0.21	8.33	13.7-19.7
9	M	18	17.19	0.24	1.00	0.17	5.84	15.4-19.2
	F	14	16.89	0.29	1.07	0.20	6.35	15.2-18.5
10	M	16	17.52	0.35	1.42	0.25	8.07	15.4-19.9
	F	20	18.66	0.26	1.17	0.18	6.25	16.8-21.0
11	M	19	18.68	0.35	1.53	0.25	8.20	16.9-23.2
	F	19	18.19	0.27	1.18	0.19	6.51	16.1-20.3
12	M	20	18.80	0.25	1.10	0.17	5.88	16.9-20.9
	F	12	19.67	0.58	2.01	0.41	10.24	17.1-23.8
13	M	12	20.92	0.57	1.97	0.40	9.43	18.2-25.7
	F	13	21.54	0.46	1.66	0.32	7.69	18.0-24.5
14	M	19	20.50	0.38	1.66	0.27	8.07	16.8-23.9
	F	4	21.40	0.82	1.64	0.58	7.66	19.3-22.8

TABLE 5.13 : *Chest Circumference (cm)*

Age group (yrs.)	Sex	No	Mean	SEM	SD	SESD	CV	Range
5	M	17	53.52	0.59	2.44	0.42	4.56	49.5-58.7
	F	12	51.49	0.69	2.39	0.49	4.64	47.5-54.6
6	M	16	55.92	0.54	2.18	0.38	3.89	52.4-59.5
	F	20	54.32	0.60	2.66	0.42	4.90	48.9-58.9
7	M	14	58.05	0.56	2.11	0.40	3.64	54.5-61.9
	F	23	56.05	0.56	2.71	0.40	4.83	50.9-61.2
8	M	13	59.48	0.88	3.18	0.62	5.34	53.9-64.0
	F	23	57.82	0.60	2.90	0.43	5.01	53.0-63.6
9	M	18	61.87	0.57	2.43	0.40	3.93	58.1-67.1
	F	14	60.01	0.80	2.98	0.56	4.96	53.4-65.1
10	M	16	63.06	1.04	3.45	0.74	6.61	54.3-70.2
	F	20	63.52	0.80	2.58	0.57	5.67	58.3-70.0
11	M	19	64.45	1.26	3.52	0.89	8.55	49.9-78.4
	F	19	62.00	0.85	2.89	0.60	6.00	54.0-68.9
12	M	20	65.17	0.93	2.89	0.66	6.36	58.9-73.5
	F	12	63.92	1.15	2.96	0.81	6.21	56.0-71.1
13	M	12	68.99	1.15	3.46	0.81	5.77	59.8-75.2
	F	13	69.69	1.17	3.54	0.83	6.07	63.1-77.8
14	M	19	71.14	0.56	4.40	0.40	3.44	66.7-74.6
	F	4	69.45	1.43	2.67	1.01	4.13	65.3-71.9

the highest at age 13 years, an increase of about 27.7% over a period of 9 years. Similarly boys have an all time high value of 20.92 cm at 13 years, an increase of about 24.7% from 15.76 cm at 5 years.

For upper arm circumference, boys have the highest CV value of 9.43% at 13 years and the lowest CV value of 4.63% at age 7 years. The corresponding figures for girls are 10.24% at 12 years and 6.16% at 7 years.

TABLE 5.14 :*Triceps Skinfold (mm)*

Age group (yrs.)	Sex	No	Mean	SEM	SD	SESD	CV	Range
5	M	17	8.29	0.52	2.14	0.37	25.85	4-12
	F	12	8.42	0.58	2.02	0.41	24.01	6-12
6	M	16	7.25	0.46	1.84	0.33	25.43	5-12
	F	20	8.60	0.37	1.64	0.26	19.01	7-13
7	M	14	6.79	0.45	1.67	0.32	24.64	4-10
	F	23	7.43	0.28	1.34	0.20	18.06	5-11
8	M	13	7.63	0.37	1.32	0.26	17.40	5-10
	F	23	8.35	0.35	1.67	0.25	19.98	6-11
9	M	18	7.00	0.50	2.14	0.35	30.20	4-11
	F	14	7.36	0.51	1.91	0.36	25.90	4-11
10	M	16	6.50	0.58	2.31	0.41	35.53	4-11
	F	20	9.50	0.34	1.50	0.24	15.84	7-13
11	M	19	7.89	0.50	2.18	0.35	27.65	4-13
	F	19	9.74	0.61	2.64	0.43	27.14	5-16
12	M	20	8.60	0.74	3.33	0.53	38.73	3-18
	F	12	11.58	0.95	3.29	0.67	28.38	7-18
13	M	12	8.83	0.37	1.27	0.26	14.35	7-11
	F	13	13.77	0.78	2.80	0.55	20.36	10-19
14	M	19	8.58	0.40	1.74	0.28	20.31	6-12
	F	4	12.50	1.04	2.08	0.74	16.65	10-15

6. *Chest Circumference* (Table 5.13, Fig. 5.3a)

The present study shows that the tendency for both sexes is towards a general increase in the chest circumference as age increases. However, males generally maintain higher values than females over the age range considered. The mean values for boys show an average increase of about 1.762 cm/year from 53.52 cm at 5 years to 71.14 cm at 14 years. Girls, with a value of 51.44 cm at 5 years show an average increase of 1.796 cm/year to reach 69.45 cm at 14 years.

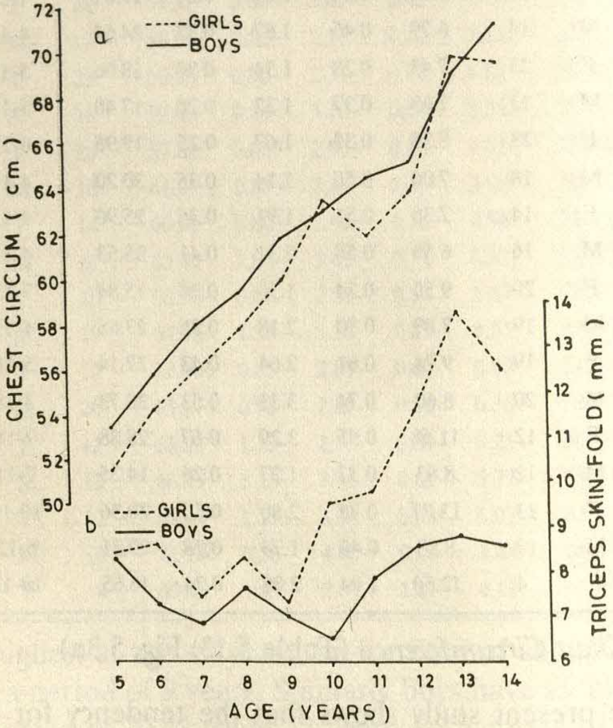

Fig. 5.3 : Distance curves for chest circumference (cm) and triceps skinfold (mm) of Kisii children.

The CV values range between 3.44% at 14 years and 8.55% at 11 years for boys and between 4.13% at 14 years and 6.21% at 12 years for girls.

7. *Triceps Skinfold (TSF)* (Table 5.14, Fig. 5.3b)

Skinfold measurements give an indication of how much energy reserves are available for the body. These reserves are in the form of fat and are available mainly at the subcutaneous layers of the body where, besides acting as energy reserves for the body, they act as insulators for the body against cold and provide the body its characteristic contours.

The general trend, as observed in the present study, shows a general decreasing tendency in the triceps skinfold upto about 9 years for girls and 10 years for boys. Thereafter, the average triceps skinfold measurement increases upto 13 years in both the sexes to be followed by a fall between 13 to 14 years. However the measurement increases more steeply among girls than among boys. The total change between 9 and 13 years among girls is of the order of 6.41 mm, while that among boys between 10 and 13 years is only 2.33 mm. As is obvious from Table 5.15 sex differences are significant ($p < 0.05$) between 10 and 14 years.

Apparently because of the nature of the subcutaneous tissue, high variations are discernible in the age changes of the measurement. The CV values for boys range between 14.35% at 13 years and 38.73% at 12 years, while for girls these values range between 15.84% at 10 years and 28.38% at 12 years.

TABLE 5.15 : *Test of Significance for Sex Differences*

Age (years)	Degrees of freedom	Weight (kg.)	Height (cm.)	Head circumference (cm.)	Upper arm circumference (cm.)	Triceps skinfold (mm.)	Chest circumference (cm.)	Sitting height (cm.)
5	27	1.2230	0.0411	3.2877***	0.4582	–0.1552	2.2280*	0.4116
6	34	0.5473	0.7010	1.8701	–0.7302	–2.3261*	1.9403	0.5300
7	35	1.4896	0.7684	3.1808***	0.7510	–1.2993	2.3606*	0.5425
8	34	0.6641	0.3912	2.4874**	0.4643	–1.3568	1.5913*	0.8409
9	30	1.6924	0.3121	3.9094***	0.8380	–0.4945	1.9462	–0.0016
10	34	–1.6452	–2.4279*	1.3801	–2.6522**	–4.7025***	–0.33494	–2.4912**
11	36	2.0932*	0.7604	3.2921***	1.1018	–2.3426*	1.6040	0.5989
12	30	–0.9757	–1.2087	1.7112	–1.5792	–2.4645**	0.8404	–1.4732
13	23	–1.5934	–0.6094	2.3382*	–0.8560	–5.5881***	–0.4257	–0.4528
14	21	–1.1330	0.0905	2.1558*	–0.9842	–3.9717***	1.2247	–0.9262

* Significant at $P = 0.05$
** Significant at $P = 0.02$
*** Significant at $P = 0.01$
–ve implies the mean value for girls is higher than that of boys.

Nutritional Status

1. Nutritional Anthropometry

(a) (i) Incidence of Malnutrition on the Basis of Weight Deficit (Gomez classification)

Use of weight in the assessment of nutritional status of an individual give the current status of the subject. It gives a picture of the not-so-long-off changes in nutritional supplies.

In the present study anthropometric measurements were taken on 324 school going children (164 boys and 160 girls) aged between 5 and 14 years. Following Gomez *et al.* (1956), they were grouped into three grades of malnutrition (Table 5.16, Fig. 5.4a & b). Out of 164 boys, 54 (32.93%) fall in the normal category, 85 (51.83%) in grade I, 23 (14.02%) in grade II and 2 (1.22%) in grade III malnutrition. In the case of girls, 58 (36.25%) were found to be normal, 78 (48.75%) were of grade I, 22 (13.75%) of grade II, and 2 (1.25%) of grade III malnutrition.

It is thus evident that only about 35% of the sampled children in the area studied, aged 5 through 14 years, are normal on the basis of Gomez classification (weight deficit). The sex distribution of normal children is, however, marginally in favour of girls (F = 36%; M = 33%). Consequently, slightly more boys (67%) than girls (64%) suffer from malnutrition.

(ii) Mean Height in Different Grades of Malnutrition

Based on the three grades of malnutrition according to the weight deficit, a comparison of heights according to the grade of malnutrition was attempted and the outcome is depicted in Table 5.17 and Figs. 5.5 and 5.6.

TABLE 5.16 : *Distribution of Kisii children in various grades of malnutrition (By weight deficit)*

Age group (yrs.)	Sex	No	Normal		Grade I		Grade II		Grade III	
			N	%	N	%	N	%	N	%
5	M	17	5	29.41	9	52.94	3	17.65	0	0
	F	12	2	16.67	9	75.00	1	8.33	0	0
6	M	16	6	37.50	8	50.00	2	12.50	0	0
	F	20	9	45.00	8	40.00	3	15.00	0	0
7	M	14	5	35.72	7	50.00	1	7.14	1	7.14
	F	23	4	17.39	16	69.57	3	13.04	0	0
8	M	13	5	38.46	6	46.15	2	15.39	0	0
	F	23	11	47.83	9	39.13	3	13.04	0	0
9	M	18	4	22.22	13	72.22	1	5.56	0	0
	F	14	5	37.71	5	37.71	3	21.44	1	7.14
10	M	16	4	25.00	8	50.00	3	18.75	1	6.25
	F	20	11	55.00	8	40.00	1	5.00	0	0
11	M	19	9	47.37	8	42.10	2	10.53	0	0
	F	19	4	21.05	9	47.37	6	31.58	0	0
12	M	20	6	30.00	12	60.00	2	10.00	0	0
	F	12	3	25.00	7	58.34	1	8.33	1	8.33
13	M	12	6	50.00	4	33.33	2	16.67	0	0
	F	13	7	53.85	5	38.46	1	7.69	0	0
14	M	19	4	21.05	10	52.63	5	26.32	0	0
	F	4	2	50.00	2	50.00	0	0	0	0
Total	M	164	54	32.93	85	51.83	23	14.02	2	1.22
	F	160	58	36.25	78	48.75	22	13.75	2	1.25
Sexes combined		324	112	34.57	163	50.31	45	13.89	4	1.23

The number of children belonging to the normal group were 112 (54 boys and 58 girls). From 5 years to 14 years the boys show a total gain in height of 45.56 cm (29.1%) from 111.14 cm while the girls show an increase of 43.85 cm (28.6%) from 109.53 cm.

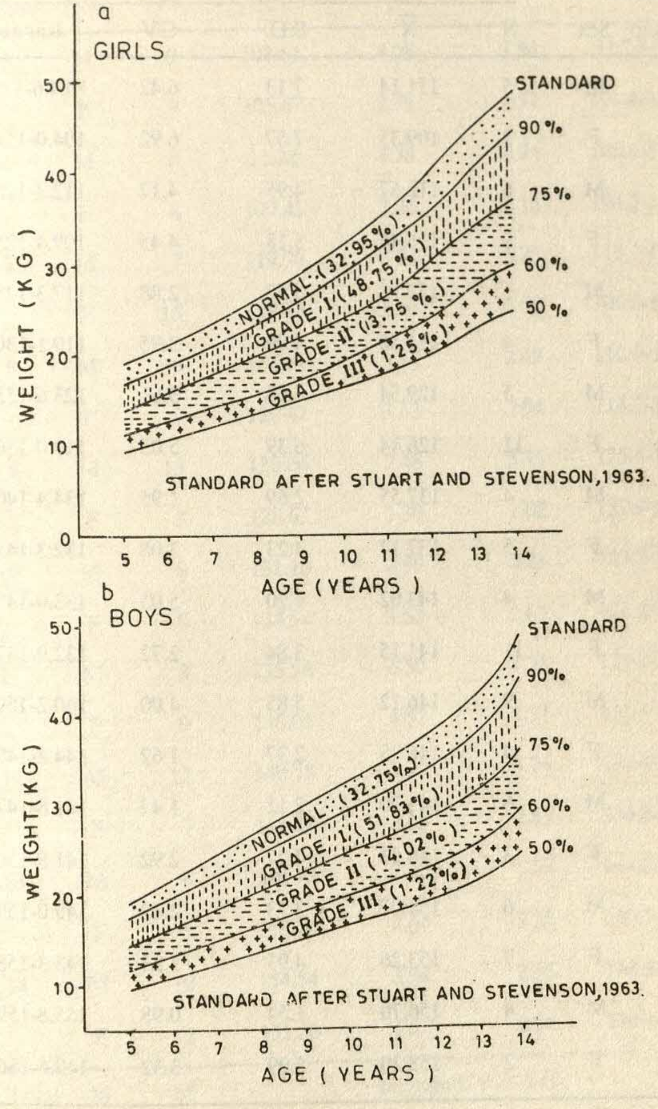

Fig. 5.4 : Incidence of malnutrition on basis of weight deficit.

TABLE 5.17 : *Mean : S.D., CV and Range for Height (cm) According to age and grade of malnutrition (sexes separate)*

Age		Normal				
group	Sex	N	$\bar{X}$	S.D.	CV	Range
5	M	5	111.14	7.13	6.42	10.4.6-122.2
	F	2	109.35	7.57	6.92	104.0-114.7
6	M	6	118.67	4.95	4.17	112.3-125.1
	F	9	116.46	5.18	4.45	109.4-125.5
7	M	5	122.18	3.52	2.88	117.3-125.5
	F	4	126.50	4.99	3.95	119.1-130.0
8	M	5	129.54	4.68	3.61	123.6-133.7
	F	11	126.44	6.39	5.03	110.0-136.4
9	M	4	137.55	2.69	1.95	134.4-140.7
	F	5	137.14	4.23	3.08	132.3-143.6
10	M	4	143.02	7.20	5.03	133.0-149.2
	F	11	141.15	3.84	2.72	132.9-147.2
11	M	9	146.12	5.85	4.00	140.2-160.0
	F	4	146.75	2.37	1.62	144.2-149.9
12	M	6	143.90	2.12	1.47	141.8-147.1
	F	3	146.53	4.27	2.92	141.8-150.1
13	M	6	154.07	3.73	2.42	149.0-159.4
	F	7	153.26	4.95	3.23	143.3-158.0
14	M	4	156.70	1.54	0.98	155.8-159.0
	F	2	153.20	5.09	3.32	149.6-156.8
Total	M	54		average CV = 3.29		
	F	58		average CV = 3.72		

TABLE 5.17 : *(Contd.)*

Age group	Sex	N	$\bar{X}$	S.D	CV	Range
		Grade I				
5	M	9	103.61	4.08	3.94	97.2-109.2
	F	9	105.67	2.71	2.57	101.4-110.4
6	M	8	11.22	4.38	3.94	103.4-115.9
	F	8	109.45	2.36	2.16	104.2-112.1
7	M	7	119.90	3.93	3.28	113.1-125.3
	F	16	116.44	4.16	3.58	106.6-122.4
8	M	6	121.01	3.17	2.62	116.9-124.4
	F	9	120.42	3.53	2.94	114.7-127.4
9	M	13	130.06	7.48	5.75	125.4-153.5
	F	3	128.63	1.30	1.02	127.4-130.0
10	M	8	131.16	2.99	2.28	127.7-136.8
	F	8	134.54	3.53	2.63	128.3-139.0
11	M	8	135.96	6.50	4.78	121.7-143.9
	F	9	138.06	4.57	3.31	131.1-142.9
12	M	12	140.78	5.29	3.76	136.8-148.4
	F	7	144.41	3.65	2.53	136.8-148.4
13	M	4	146.48	2.30	1.57	144.2-148.6
	F	5	148.98	4.84	3.25	140.7-152.4
14	M	10	154.54	3.94	2.55	148.3-162.0
	F	2	151.30	1.27	0.84	150.4-152.2
Total	M	85		average CV = 3.45		
	F	76		average CV = 2.48		

TABLE 5.17 : *(Contd.)*

Age group	Sex	Grade II				
		N	$\overline{X}$	S.D	CV	Range
5	M	3	101.50	0.30	0.30	101.2-101.8
	F	1	94.70	--	--	--
6	M	2	104.55	1.06	1.01	103.8-105.3
	F	3	103.53	1.76	1.70	102.1-105.5
7	M	1	115.20	--	--	--
	F	3	108.93	2.07	1.90	106.7-110.8
8	M	2	112.85	0.35	0.31	112.6-113.1
	F	3	111.00	3.42	3.08	107.4-114.2
9	M	1	118.60	--	--	--
	F	5	126.34	6.18	4.89	122.3-137.3
10	M	3	123.80	5.25	4.24	118.5-129.0
	F	1	126.10	--	--	--
11	M	2	131.85	3.18	2.41	129.6-134.1
	F	6	133.98	2.71	2.02	131.0-137.8
12	M	2	132.45	5.73	4.32	128.4-136.5
	F	1	141.40	--	--	--
13	M	2	140.55	1.34	1.00	139.6-141.6
	F	1	142.50	--	--	--
14	M	5	145.22	7.82	5.39	136.3-155.1
	F	--	--	--	--	--
Total	M	23		average CV = 1.90		
	F	24		average CV = 1.36		

Table 5.17 : *(Contd.)*

Age group		Grade III					Total gain between Grade I and II	
	Sex	N	$\bar{X}$	S.D	CV	Range	absolute	%
5	M	--	--	--	--	--	2.11	2.04
	F	--	--	--	--	--	10.97	10.38
6	M	--	--	--	--	--	6.67	6.00
	F	--	--	--	--	--	5.92	5.41
7	M	1	99.4	--	--	--	4.70	3.92
	F	--	--	--	--	--	7.51	6.45
8	M	--	--	--	--	--	8.16	6.74
	F	--	--	--	--	--	9.42	7.82
9	M	--	--	--	--	--	11.46	8.81
	F	1	120.3	--	--	--	2.29	1.78
10	M	1	117.7	--	--	--	7.36	5.61
	F	--	--	--	--	--	8.44	6.27
11	M	--	--	--	--	--	4.11	3.02
	F	--	--	--	--	--	4.08	2.96
12	M	--	--	--	--	--	8.33	5.92
	F	1	128.4	--	--	--	2.91	2.02
13	M	--	--	--	--	--	5.93	4.05
	F	--	--	--	--	--	6.48	4.35
14	M	--	--	--	--	--	9.32	6.03
	F	--	--	--	--	--	--	--
Total	M	2				average CV = --		
	F	2				average CV = --		

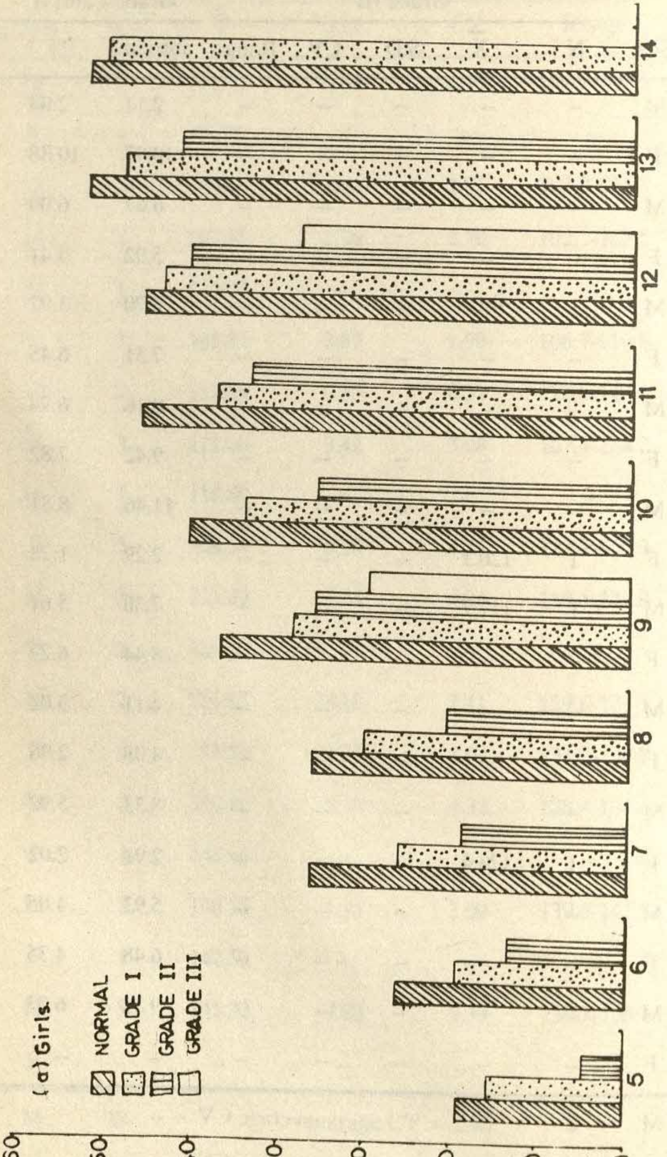

Fig. 5.5 : Mean height (cm) at each age and nutritional status of Kisii children (girls) using weight deficit method.

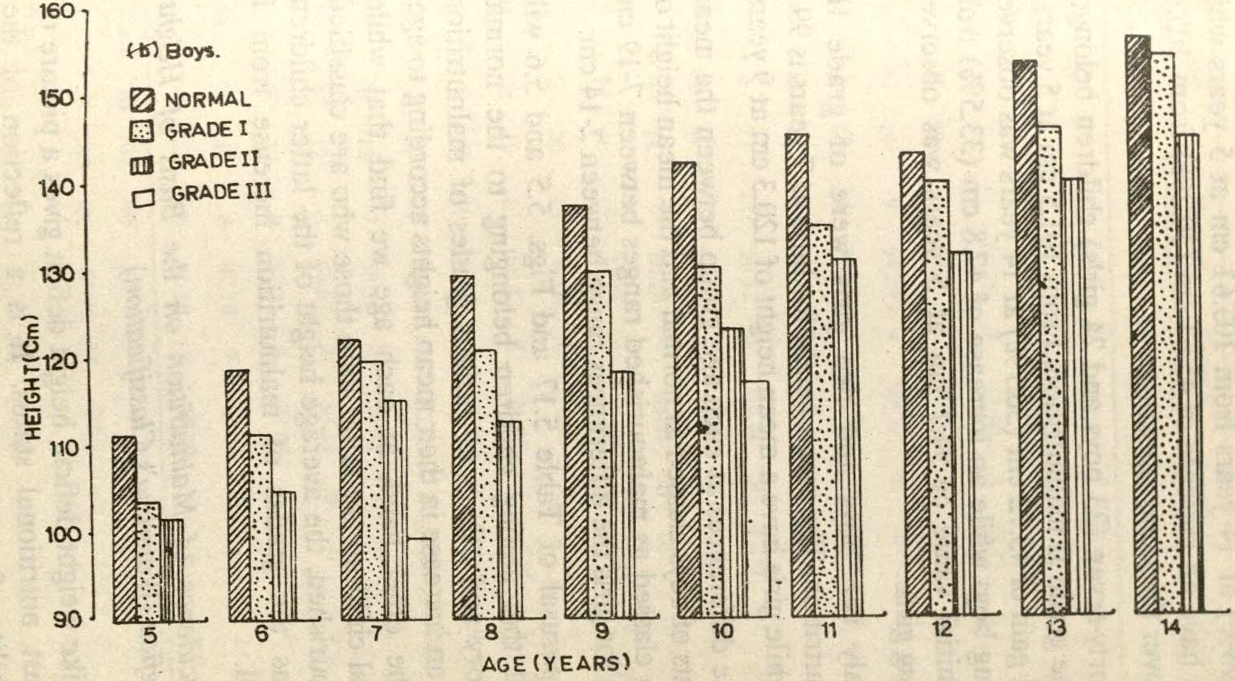

Fig. 5.6 : Mean height (cm) at each age and nutritional status of Kisii children (boys) using weight deficit method.

Grade I malnutrition, included 161 children (85 boys and 76 girls). Boys show a total increase of 50.93 cm (32.96%) at 14 years from 103.61 cm at 5 years while girls have an increase of 45.63 cm (30.2%) from 105.67 cm over the same age range.

Forty-seven (23 boys and 24 girls) children belonged to the grade II malnutrition. From 101.5 cm at 5 years a total gain of 43.72 cm (30.1%) at 14 years was observed among boys while an increase of 47.8 cm (33.5%) from an initial value of 94.7 cm at 5 years was observed among girls.

Only two boys and two girls were of grade III malnutrition. The mean height for boys at 7 years is 99.4 cm while girls have a mean height of 120.3 cm at 9 years.

The differences at each age group between the mean heights of boys classed as normal and the mean height of those classed as malnourished ranges between 7-19 cm while for girls the differences range between 2-14 cm.

A perusal of Table 5.17 and Figs. 5.5 and 5.6 will reveal that among children belonging to the normal category and others to various grades of malnutrition show an increase in their mean heights according to age. On the other hand, at each age we find that while normal children are taller than those who are classified malnourished, the average height of the latter children falls as the grades of malnutrition increase from I and III.

(*b*) *Incidence of Malnutrition on the Basis of Height Deficit (Waterlow's Classification)*

Unlike weight deficit, height deficit gives a picture of the past nutritional status. It is a reflection of the availability of nutrients to the body over a period of

TABLE 5.18 : *Distribution of Kisii children in various grades of malnutrition (By height deficit)*

Age group (yrs.)	Sex	No	Normal		Grade I		Grade II		Grade III	
			N	%	N	%	N	%	N	%
5	M	17	7	41.18	8	47.06	2	11.76	0	0
	F	12	8	66.67	3	25.00	1	8.33	0	0
6	M	16	11	68.75	2	12.50	3	18.75	0	0
	F	20	12	60.00	6	30.00	2	10.00	0	0
7	M	14	9	64.29	4	28.57	0	0	1	7.14
	F	23	14	60.87	5	21.74	4	17.39	0	0
8	M	13	7	53.84	3	20.08	3	20.08	0	0
	F	23	13	56.52	5	21.74	4	17.39	1	4.35
9	M	18	9	50.00	8	44.44	1	5.56	0	0
	F	14	9	64.29	5	35.71	0	0	0	0
10	M	16	5	31.25	8	50.00	1	6.25	2	12.50
	F	20	18	90.00	2	10.00	0	0	0	0
11	M	19	13	68.42	4	21.06	1	5.26	1	5.26
	F	19	10	52.63	9	47.37	0	0	0	0
12	M	20	11	55.00	7	35.00	2	10.00	0	0
	F	12	7	58.34	4	33.33	0	0	1	8.33
13	M	12	8	66.67	4	33.33	0	0	0	0
	F	13	9	69.23	3	23.08	1	7.69	0	0
14	M	19	8	42.10	9	47.37	0	0	2	10.53
	F	4	2	50.00	2	50.00	0	0	0	0
Total	M	164	88	53.66	57	34.76	13	7.92	6	3.66
	F	160	102	63.75	44	27.50	12	7.50	2	1.25
Sexes combined		324	190	58.64	101	31.17	25	7.72	8	2.47

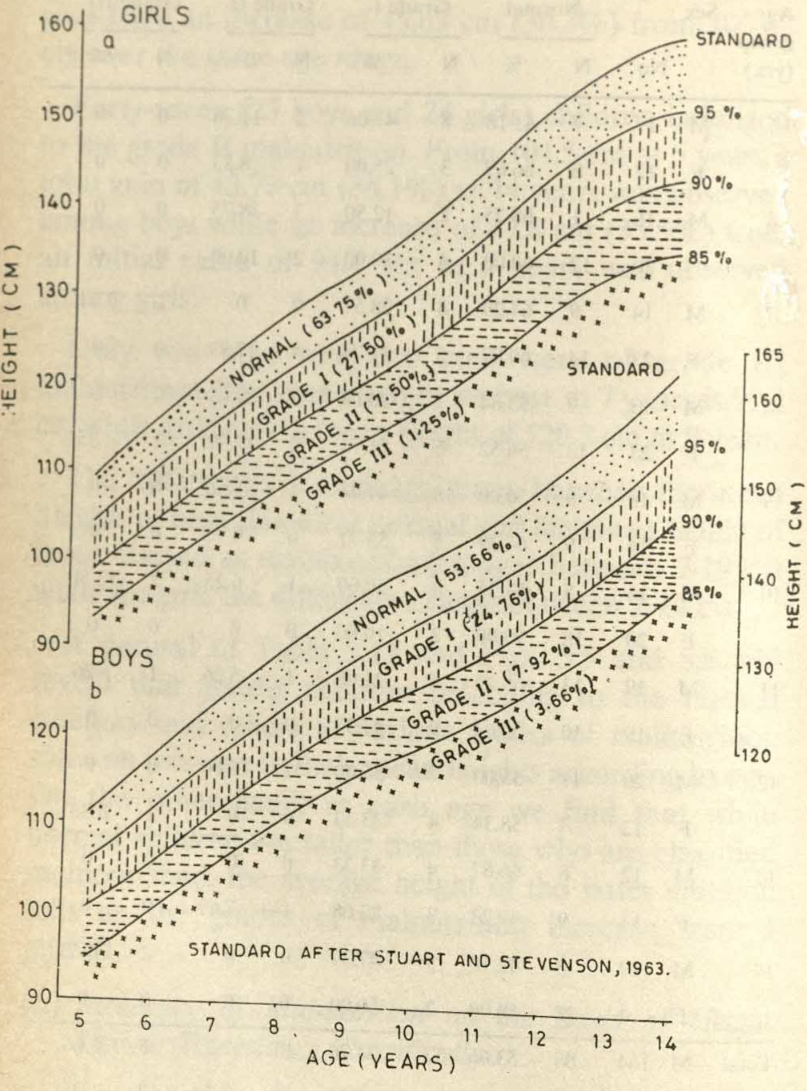

Fig. 5.7 : Incidence of malnutrition on basis of height deficit.

time. If the supplies have been inadequate the individual will be stunted, that is, will have less height than expected for his age.

Table 5.18 presents distribution of various grades of malnutrition according to age on the basis of height deficits. The distribution for the whole sample, according to sex, is also depicted in Fig. 5.7a and b. Out of a total of 164 boys, 88 (54%) were found to be of normal height, 57 (35%) fell in grade I (marginal malnutrition), 13 (8%) in grade II (moderate malnutrition), and 6 (4%) in grade III (severe malnutrition). Out of a total of 160 girls, 102 (64%) fall under the normal category, 44 (27.5%) under grade I (marginal malnutrition), 12 (7.5%) under grade II (moderate malnutrition) and 2 (1%) under grade III (severe malnutrition). Fifty-eight per cent of the children, irrespective of their sex, showed normal height for their age.

(c) Incidence of Malnutrition as. Observed from the Triceps Skinfold Measurement

Body fat reserves are very important in times of emergency when there are inadequate or no external supplies and, therefore, the body has to rely upon the internal reserves for its energy requirements. The more the reserves the better an individual is to endure such conditions for a slightly longer period than one with less reserves.

In the present study it may be observed from Table 5.19 and Fig. 5.8a and b that 46% of the children surveyed (45% boys, 47% girls) are normal, 22.8% (23.2% boys, 22.5% girls) are of grade I malnutrition, 23.5% (22% boys, 25% girls) are of grade II malnutrition and 7.7% (9.8% boys, 5.6% girls) are of grade III malnutrition corresponding to mild, moderate

TABLE 5.19 : *Distribution of Kisii Children in Various Grades of Malnutrition (Using triceps skinfold measurement)*

Age group (yrs.)	Sex	No	Normal		Grade I		Grade II		Grade III	
			N	%	N	%	N	%	N	%
5	M	17	8	47.06	3	17.65	4	23.53	2	11.76
	F	12	5	41.67	3	25.00	4	33.33	0	0
6	M	16	5	31.25	5	31.25	6	37.50	0	0
	F	20	10	50.00	4	20.00	6	30.00	0	0
7	M	14	4	28.57	5	37.72	4	28.57	1	7.14
	F	23	4	17.39	7	30.43	11	47.83	1	4.35
8	M	13	7	53.85	5	38.46	1	7.69	0	0
	F	23	10	43.48	3	13.04	7	30.44	3	13.04
9	M	18	7	38.89	3	16.67	4	22.22	4	22.22
	F	14	2	14.29	3	21.43	6	42.86	3	21.43
10	M	16	3	18.75	2	12.50	7	43.75	4	25.00
	F	20	10	50.00	8	40.00	2	10.00	0	0
11	M	19	6	31.58	4	21.05	6	31.58	3	15.79
	F	19	9	47.37	5	26.31	3	15.79	2	10.53
12	M	20	11	55.00	5	25.00	2	10.00	2	10.00
	F	12	9	75.00	2	16.67	1	8.33	0	0
13	M	12	10	83.33	2	16.67	0	0	0	0
	F	13	13	100.00	0	0	0	0	0	0
14	M	19	13	68.42	4	21.05	2	10.53	0	0
	F	4	3	75.00	1	25.00	0	0	0	0
Total	M	164	74	45.12	38	23.17	36	21.95	16	9.76
	F	160	75	46.88	36	22.50	40	25.00	9	5.62
Sexes combined		324	149	45.99	74	22.84	76	23.45	25	7.72

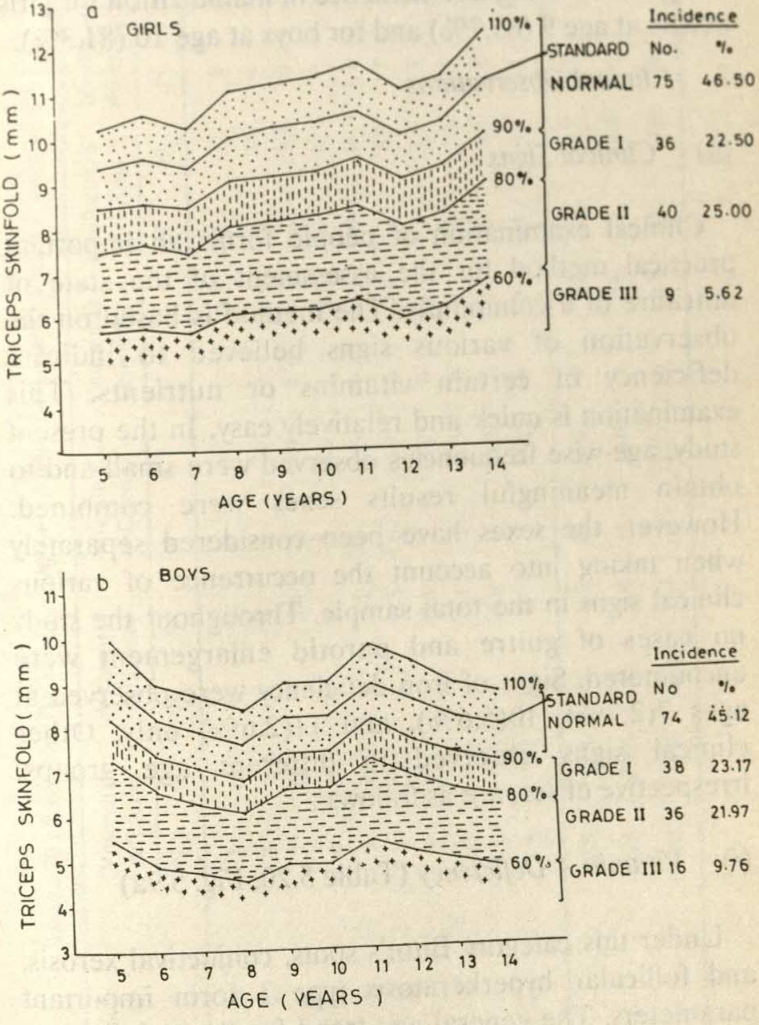

Fig. 5.8 : Incidence of malnutrition using TSF in Kisii children.

and severe types respectively. Thus, 54% of the children studied may be said to be malnourished (85.7% of these are in grade I or II types of malnutrition) on the basis of triceps skinfold measurement.

Agewise the highest incidence of malnutrition for girls occurs at age 9 (85.7%) and for boys at age 10 (81.3%).

2. *Clinical Observations*

(a) Clinical Signs

Clinical examination of people forms an important practical method for the assessment of the state of nutriture of a community. The method is based on the observation of various signs believed to indicate deficiency of certain vitamins or nutrients. This examination is quick and relatively easy. In the present study, age-wise frequencies observed were small and to obtain meaningful results sexes were combined. However, the sexes have been considered separately when taking into account the occurrence of various clinical signs in the total sample. Throughout the study no cases of goitre and parotid enlargement were encountered. Signs of iron deficiency were observed at ages 7(2.7%), 10(5.6%), and 11(2.6%) only. Other clinical signs observed in different age groups, irrespective of sex, are as follows :

(*i*) *Vitamin A Deficiency* (Table 5.20; Fig. 5.9a)

Under this category Bitot's spots, conjuctival xerosis, and follicular hyperkeratosis type 1 form important parameters. The general age trend for these deficiency signs as a category is to show an increase upto about 12 years followed by an abrupt fall in frequencies at 13 and 14 years.

TABLE 5.20 : *Percentage Prevalence of Different Nutritional Deficiency Signs (sexes combined)*

Age group (yrs.)	No	Vitamin A deficiency		Vitamin B deficiency		Vitamin C deficiency		Vitamin D deficiency		Incidence of flourosis		Incidence of dental caries		Iron deficiency	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%
5	29	3	10.3	0	0	0	0	1	3.5	1	3.5	9	31.0	0	0
6	36	2	5.6	0	0	1	2.8	3	8.3	2	5.6	6	16.7	0	0
7	37	7	18.9	2	5.4	2	5.4	1	2.7	2	5.4	10	27.0	1	2.7
8	36	6	16.7	0	0	7	18.9	1	2.8	0	0	6	16.7	0	0
9	32	5	15.6	1	3.1	4	12.5	1	3.1	0	0	2	6.3	0	0
10	36	8	22.2	3	8.3	6	16.7	2	5.6	3	8.3	7	19.4	2	5.6
11	38	9	23.7	2	5.3	7	18.4	0	0	3	7.9	5	13.2	1	2.6
12	32	10	31.3	1	3.1	2	6.3	0	0	1	3.1	3	9.4	0	0
13	25	1	4.0	2	8.0	4	16.0	1	4.0	2	8.0	3	12.0	0	0
14	23	2	8.7	0	0	5	21.7	0	0	1	4.4	1	4.4	0	0
Total M		28	17.1	7	4.3	22	13.4	9	5.5	8	4.9	31	18.9	4	2.4
F		25	15.6	4	2.5	16	10.0	1	0.6	7	4.4	21	13.1	0	0
Sexes combined		53	16.4	11	3.4	38	11.7	10	3.1	15	4.6	52	16.05	4	1.2

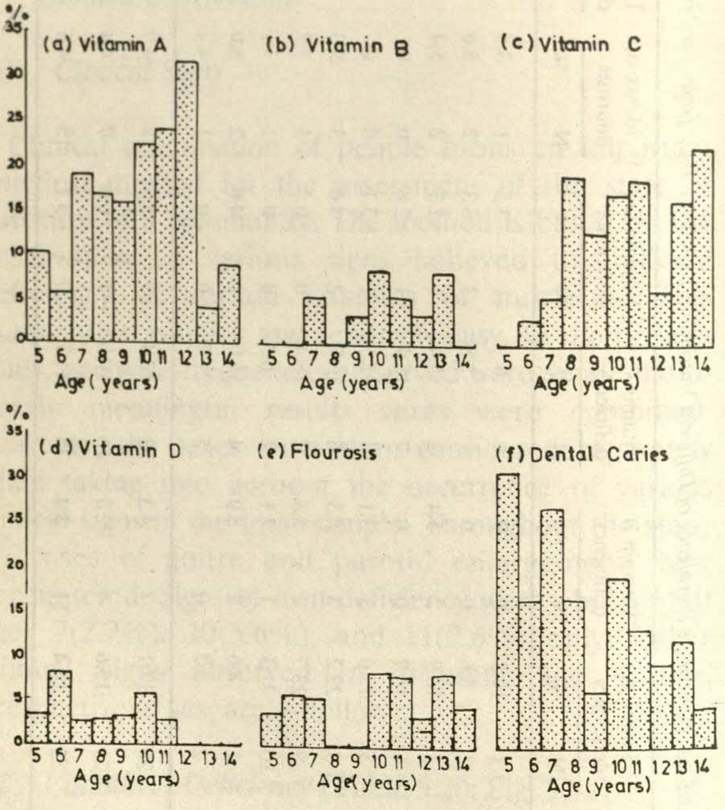

Fig. 5.9 : Incidence of clinical signs according to age (sexes combined).

(*ii*) *Vitamin B Complex Deficiency* (Table 5.20; Fig. 5.9b)

Vitamin B Complex deficiency signs include clinical features like angular stomatitis, cheilosis, atrophic papillae and pellagrous dermatosis. The incidence of this vitamin deficiency is quite low as compared to vitamin A and C. At 7 years it occurred with a frequency of 5.4% to reach a high value of 8.3% at 10 years.

(*iii*) *Vitamin C Deficiency* (Table 5.20, Fig. 5.9c)

The deficiency of this vitamin, also known as scurvy, is characterised by swollen and bleeding gums. The incidence of this vitamin deficiency is high reaching a value of 21.7% at 14 years. In general it shows a tendency to increase from 5 years through 14 years.

(*iv*) *Vitamin D Deficiency* (Table 5.20, Fig. 5.9d)

This deficiency disease, characterised by knock-knees or bow legs, is also known as rickets in the young or osteomalacia in the adults. The incidence of this vitamin deficiency maintains an average prevalence of about 2.9% but after 12 years it drops to zero.

The summary information in respect of total prevalence of these deficiency signs is given in Fig. 5.10a. In general, boys maintain a higher incidence than do girls. The prevalence is highest in vitamin A deficiency, followed, in decreasing order, by vitamin C deficiency, Vitamin B deficiency, Vitamin D deficiency and by iron deficiency.

(*b*) *Oral Hygiene*

(*i*) *Incidence of Flourosis* (Table 5.20, Fig. 5.9e)

This is characterised by mottled enamel. The incidence of this particular clinical feature shows a

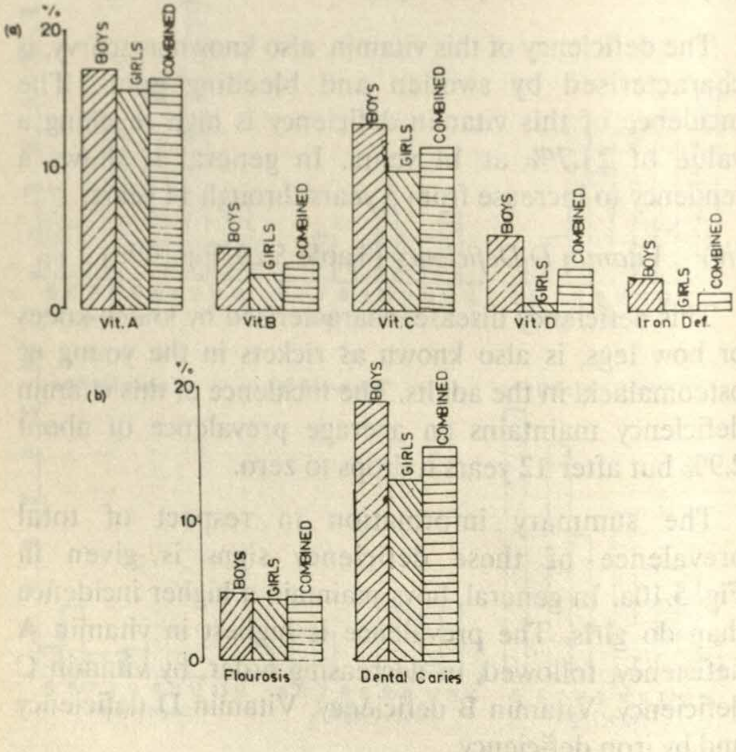

Fig. 5.10 : Incidence of clinical signs according to sex (ages combined).

prevalence of 3.5% at 5 years. In general, it shows an average frequency of about 5% (Fig. 5.10b).

(*ii*) *Incidence of Dental Caries* (Table 5.20. Fig. 5.9f)

This is characterised by cavities produced by certain micro-organisms that live on the teeth and produce acids from ingested sugars and starches. The general trend, as depicted in Fig. 5.9f, is for this variable to show a decrease throughout the entire study period. The highest incidence (31%) occurs at 5 years and the lowest incidence (4.4%) occurs at 14 years.

In Fig. 5.10 it is again observed that boys maintain slightly higher prevalence rate than do girls. However, in case of flourosis the difference is very small (0.5%) as compared to that of dental caries (5.8%).

6

Discussion

Ecological Factors

Beyond the quite considerable physiological flexibility of man to dietary imbalances lie extreme conditions of nutritional stress. In such stresses, health and physical states may be affected even from the prenatal period, when the child is in its mother's womb. Throughout human life the body has to adapt to stresses as and when they occur. Nutritional stresses in man are a reflection of his ecology, culture and biology. The direct effect of climate upon dietary demands, the disease environment that must be endured and the food producing potential of an area are ecological factors. The demographic changes and the degree of adaptation to stress conditions are biological factors (Newman, 1962).

The food producing pattern of the Kisii people is modulated by precipitation throughout the year. The type of foods grown and the time when they are grown are cultural patterns governed by knowledge of the people about their environment vis-a-vis the type of foods to be grown. Inter-planting is done in the main crop so that maximum utility of the cultivable area is derived. This is further necessitated by the fact that the landholdings per capita are decreasing (the population density in most parts of the district is over 400 persons/ sq. km and in some places close to or over 1000 persons/ sq. km (CBS, n.d.)). In some places, especially the warmer areas and using certain maize varieties, it is possible to realise two harvests in a year.

Crop rotation is done from time to time. This enables soils to rest and regain their lost nutrients. The Kisii people possess simple technology for exploiting the environment. Cultivation is done using hand-hoe or, when financial resources permit, oxen-pulled plough. In Kenya, it is the women-folk who provide most of the on-farm labour and children from an early age onwards typically work - part-time on small farm-holdings. Maximum participation rates among children are seen during the peak seasons (Frank and McNicoll, 1987). In general, women in Kisii spend a considerable amount of their time and energy in activities related to food production.

In times of plenty. food is stored in special structures (barns) awaiting for times when adverse conditions reverse the order. Other crops like sweet potatoes and bananas are capable of withstanding prolonged droughts and the presence of these foods in the Kisii people's diet may be seen to have a survival value. This is especially necessary since the terrain does not seem to favour economical irrigation.

Social obligations ensure that people do not die of starvation. Thus, when a women, who cannot fend for her children, comes for help from a neighbour she may not be turned away. It is the responsibility of every mother to make sure that the young are well fed. Also, it is a source of pride to help those who are in need. Nevertheless, whatever the circumstances under which such food is given, it ensures that those who do not have sufficient material resources to keep them going during stress conditions get atleast some support from other members of the community.

In this study it is revealed that quite a number of homes were headed by a farmer (61.6%) most of whom had no formal education. Those in the professional jobs were mainly teachers. The study further reveals a sex difference in regard to the level of education attained. A large proportion of males in comparison to females are literate. This could be because of the traditional role of women in providing on-farm labour and childbearing activities. Ignorance, especially of the female population, of the principles of proper nutrition and personal hygiene considerably apparent in the rural areas (Pharaon, 1970) could be a significant contribution to their nutritional status. Illiterate mothers may not be in a position to appreciate nutritional education as taught by field health educators. During the many field tours by one of the investigators accompanied by an health educator or a nutritionist, it was not uncommon, in the presence of these people, for mothers to say that children are provided with eggs and fruits. But on follow-up visits and intensive cross-examination the contrary was found to be the case. It became clear that most of the mothers did not practice what they profess or were instructed by the health educators. This could be attributed to their poverty and/or ignorance in line with Barton's (1970) observation that apart from climatic conditions, malnutrition may be "more generally the result of ignorance of nutritional or health requirements and/or agricultural practice".

Though no specific information was sought from the mothers on this score, but indirect evidence indicates that diarrhoea, the most frequent form of gastrointestinal infection, is quite high in children under 5 years. Only slightly more than 50% of the mothers reported taking their children for diarrhoeal and other form of treatment to the Keroka Health Centre. In diseased conditions the energy requirements are altered. If these alterations are in a manner such that there is no concordance between the energy requirements and the specific demand for them, malnutrition results. Malnutrition and infection are thought of as acting in a synergestic manner upon each other (Edirisinghe, 1986; Glazebrook and Davis, 1979; and Scrimshaw *et al.*, 1968). The role played by diarrhoea in the aetiology of malnutrition has been shown by a number of researchers (Gordon, *et al.*, 1968; Mata *et al.*, 1971; Martorell *et al*, 1975a and Jenkins, 1981). Diarrhoea when present decreases the appetite of an individual, and causes nutrient malabsorption due to rapid intestinal transit time (Gates-Williams and Tervalon, 1988) with the result that the body is not able to replenish the lost nutrients in time. If diarrhoeal infections are prolonged or if it is of the chronic type, cessation of linear growth occurs with little or no catch-up growth after recovery (Black *et al.*, 1984). Martorell *et al.*, (1975a) in studies carried out among the Guatemalan children have shown that diarrhoeal infections can cause upto to 10% of the total growth retardation in length and weight by age 7 years. These changes are then reflected in the older age groups in terms of stuntness, or reduced height in comparison with the expected height at their age if they were normal.

Kisii children were found to be weaned into carbohydrate foods and this becomes their main source of nutrients throughout life. Maize is the staple food for the Kisii people. Almost all main meals are prepared from maize or its derivatives. Studies done on other populations (Behrend, 1978) reveal that adaptation of maize horticulture and its subsequent utilization increases the carbohydrate content and as a result changes the epidemiological pattern of caries. Highly milled carbohydrates or use of sugars are associated with increased tendencies towards dental caries (Jelliffe, 1966). In the present study, dental caries occurs at a rate of 16.05% (Table 5.20). It is probable that dental caries may be as a result also of poor oral hygiene which may act as a causative or simply as an enhancing agent.

Living conditions of Kisii people may be described as satisfactory (Table 5.1a). The predominant sources of water are rivers and springs, and quite a high proportion do not boil water. But this is because a large number of people have access to piped water.

The foods consumed by most families are mainly carbohydrate in origin. People derive proteins from milk but the production is quite low. Bean consumption was reported to be high but this might be due to the fact that harvesting was done during the time when data collection was in progress. Because of the long process involved in the preparation of beans, many families prefer growing them for the purpose of earning cash. Beans are mainly sold to boarding schools.

Physical Growth

Auxological studies give a reflection of the whole composite nature of genetic and environmental influences that determine growth and developmental trends in man. While growth is under the control of genes, environmental factors such as the psychological features, nutritional supplies and many other factors determine the ultimate potential the individual will accomplish. These influences, genetic or environmental, occupy an important section in anthropological studies dealing with auxology and nutrition.

In the present study, weight, and other linear measurements like height, and sitting height, circumferences like chest circumference and upper arm circumference, and the triceps skinfold bear an almost linear relationship with age. This is amply shown by the regression lines drawn for all these measurements against age (Fig. 6.1a to g). The regression equations and the respective coefficients of correlation (r) are presented below :

Males :

Wt. = 3.41469 + 2.51142 Age, r = 0.991
Ht. = 82.48666 + 5.06624 Age, r = 0.994
HC. = 50.84264 + .23833 Age, r = 0.965
UAC. = 12.63834 + .55007 Age, r = 0.969
TSF. = 6.47020 + .13381 Age, r = 0.467
CC. = 44.81100 + 1.82220 Age, r = 0.992
SH. = 49.03641 + 1.77400 Age, r = 0.983

Females

Wt. = .28765 + 2.83518 Age, r = 0.979
Ht. = 78.81254 + 5.52309 Age, r = 0.991
HC. = 49.41183 + .26438 Age, r = 0.926
UAC. = 11.86432 + .65333 Age, r = 0.932
TSF. = 3.97585 + .59193 Age, r = 0.802
CC. = 42.24211 + 1.96218 Age, r = 0.974
SH. = 46.80341 + 2.06477 Age, r = 0.995

Abbreviation :

Wt. = Weight, kg.; Ht = Height, cm.; H.C. = Head Circumference, cm.; UAC = Upper Arm Circumference, cm; TSF = Triceps Skinfold, mm; CC = Chest Circumference, cm; SH = Sitting height, cm.

all values of r insignificant at $P < 0.05$.

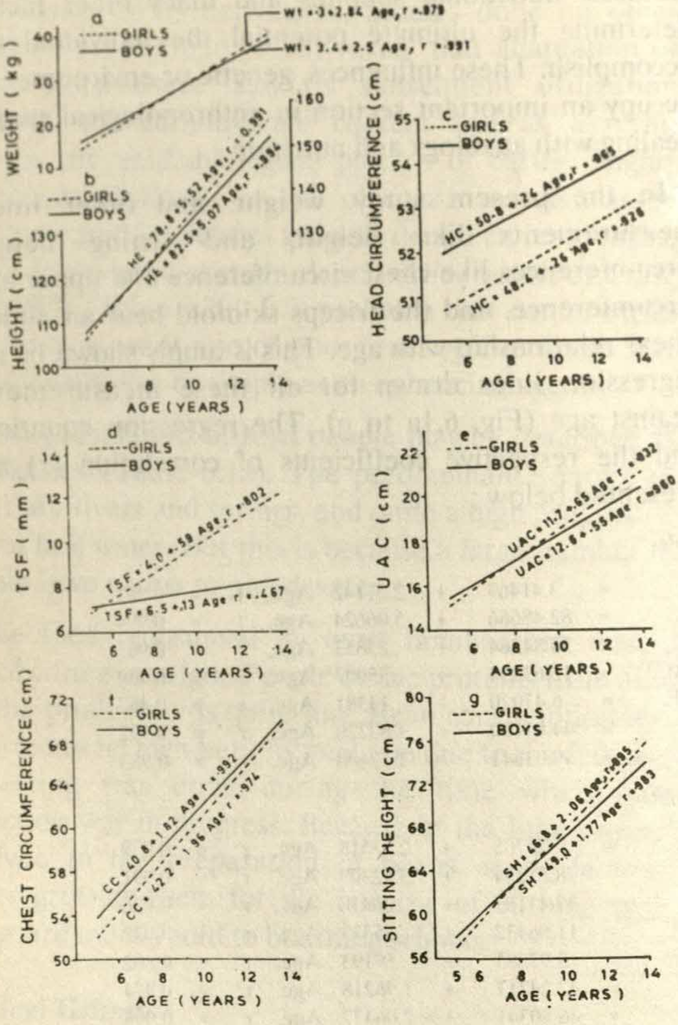

Fig. 6.1 : Regression Lines for Kisii Boys and Girls.

A perusal of regression lines (Fig. 6.1a to g) indicates that boys have head and chest circumferences which are quite larger throughout the age range than girls of the same average ages. For weight, height, sitting height, and upper arm circumference, while boys start with higher average values, by about 9 years girls overtake them and gradually the lines diverge a little from each other as age increases.

As regards the triceps skinfold (Fig.6.1d) girls almost from the beginning (from 6 years onwards) exhibit a considerably diverging trend with increase in age. This is also obvious from the values for the slope (b) of the trend lines. The values for 'b' are as follows :

boys = 0.1338
girls = 0.59193

The head and face has a pattern of growth that is quite different from that of the rest of the body. At young ages, the growth of the head is well advanced in its development compared to (say) height (Hauspie, 1980). About 70% of the adult height is achieved by the age of 6 years, but the head has already completed about 90% of its adult size by that age (Baughan, *et al*, 1979). Tanner (1962) reports that the head- length, -breadth and -circumference are about 96% of the adult size at the age of 10 years. The type of growth exhibited by height is of the visceral type, corresponding to the general growth of the skeletal system, and that of head-length, -breadth and -circumference is of the neural type (Tanner, 1962). The basic sex differences in the head appear during foetal development. At birth boys have already larger head circumferences than girls (Miklashevskaya, 1969). Other workers who have shown that the boys are ahead of girls in head circumference include Goldstein (1936), Hautvast (1971a), and Meredith (1971). In the present study on Kisii children from Kenya, the average head circumference throughout the age range (5-14 years) is considerably larger in boys than in girls. The boys, on an average, lead the girls by 1.25 cm. On the basis of world-wide reports, Nellhaus (1968) was able to show that the mean increments in head circumference from birth to 18 years are nearly the same for both sexes during most intervals. On an average, Nellhaus (1968) showed that head circumference for boys at all ages is approximately 0.9 cm larger than that for girls. Comparisons between Kisii children of Kenya and the Nyakyusa and Kisi children of Tanzania (Table 6.2 and Fig. 6.3b and d) reveal that the Kisii boys show higher values than either the Nyakyusa or the Kisi of Tanzania. The Nyakyusa girls initially show smaller head circumferences, but after 11 years their (Nyakyusa girls') curves take the upper course. The Kisi children (Tanzania) have smaller values than those for the Kisii children (present study) and the Nyakyusa children.

Average weights and heights of Kisii children compared with NCHS (1977) standards are given in Fig. 6.2a and b. The results show that for weight, Kisii boys and girls show a similar pattern of growth but the curves are much below the NCHS 50th percentile line and generally above the NCHS 10th percentile. The pattern of height growth is similar, but the Kisii curves run along the NCHS 20th percentile line.

The average values for weight, height, upper-arm circumference, sitting height, derived leg-length and the triceps skinfold have also been compared with those of Mexican-American (US) children (Martorell, *et al*, 1988 and Zavaleta and Malina, 1980), the Turkana pastoralist

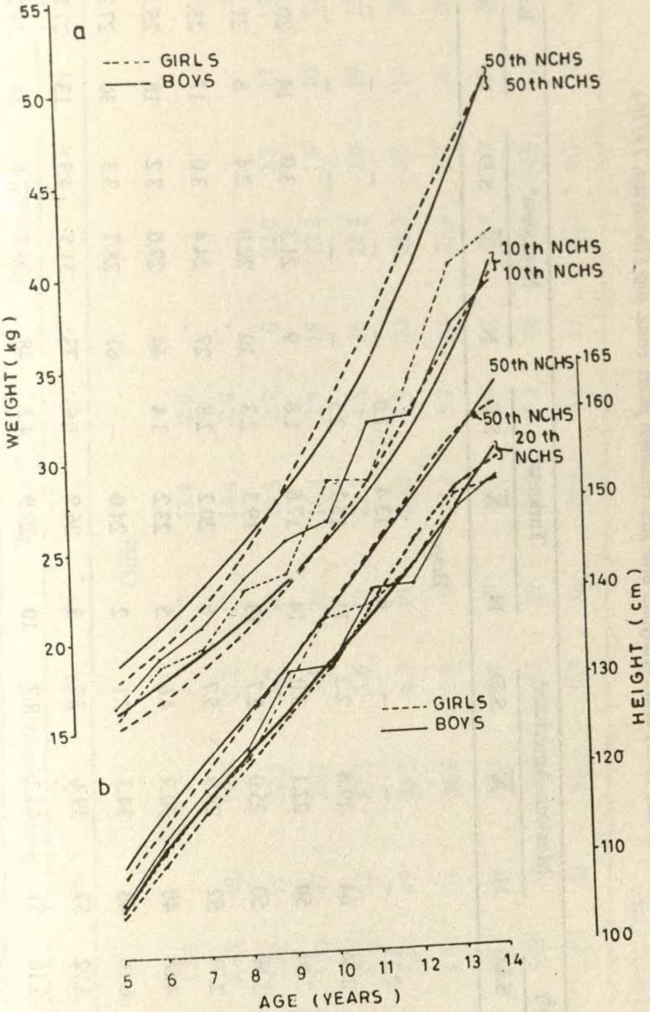

Fig. 6.2 : Kisii weight and height mean values compared with NCHS (1977) curves.

TABLE 6.1 : *Mean values for weight, height, UAC and TSF compared with Mexican-American children (Zavaleta & Malina, 1980), the Turkana pastoralists (Little et al., 1983) and Nyakyusa and Kisi children from Tanzania (Hautvast, 1971b)*

(i) Weight (kg)

Age	Present study			Mexican-American[a]			Turkana[b]			Nyakyusa[c]			Kisi[c]		
(yrs.)	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.
							Boys								
5	17	16.47	2.11	--	--	--	6	13.4	1.0	--	--	--	--	--	--
6	16	19.09	2.38	64	19.8	2.2	11	15.1	2.5	--	--	--	--	--	--
7	14	20.89	2.81	50	22.1	3.0	14	17.6	1.8	9	21.5	3.0	14	20.2	1.9
8	13	23.54	3.50	50	25.0	2.7	13	19.3	2.3	10	22.0	2.4	8	21.5	2.9
9	18	25.64	2.71	52	28.9	5.7	6	20.2	2.8	27	24.4	3.0	17	23.7	2.9
10	16	26.59	4.88	48	30.9	4.6	5	23.2	3.4	44	27.0	3.2	18	25.1	2.7
11	19	32.03	6.10	48	34.3	7.1	2	24.0	--	61	28.7	3.3	30	27.3	3.3
12	20	32.10	3.92	57	39.1	7.7	3	26.9	1.6	73	31.5	4.9	13	27.2	3.9
13	12	37.12	5.16	51	44.2	8.7	10	29.9	4.2	48	33.9	3.6	16	31.2	3.7
14	19	39.53	4.64	52	48.5	8.6	6	28.1	4.8	51	40.2	4.9	5	30.2	3.7

TABLE 6.1 : *(Contd.)*

Age	Present study			Mexican-American[a]			Turkana[b]			Nyakyusa[c]			Kisi[c]		
(yrs.)	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.
							Girls								
5	12	15.62	1.33	-	-	-	7	13.4	2.0	-	-	-	-	-	-
6	20	18.65	2.45	48	19.5	2.7	17	14.4	2.0	-	-	-	-	-	-
7	23	19.65	2.22	51	22.3	3.2	18	18.3	2.7	8	22.0	2.8	12	19.6	2.1
8	23	22.80	3.00	47	23.7	3.5	20	18.4	2.9	18	22.2	1.9	10	21.0	2.9
9	14	23.75	3.62	52	27.5	5.6	20	21.7	4.5	36	24.3	2.0	19	23.5	2.5
10	20	28.90	3.52	49	33.1	6.5	16	23.2	3.5	52	26.2	2.5	12	24.1	1.7
11	19	28.68	3.35	53	36.6	7.9	9	24.4	5.7	62	27.9	3.3	26	28.5	4.5
12	12	34.25	8.54	50	43.3	8.8	9	29.3	5.4	81	33.7	4.7	9	29.4	5.8
13	13	40.38	5.06	51	44.8	8.7	19	29.7	5.2	48	38.3	4.9	11	29.9	5.0
14	4	42.25	2.06	65	50.2	9.3	16	32.8	5.6	47	42.7	6.7	7	34.0	4.4

[a] Zavaleta & Malina, 1980

[b] Little *et al.*, 1983

[c] Hautvast, 1971b

Table 6.1 : *(Contd.)*

(ii) Height (cm)

Age	Present study			Mexican-American			Turkana			Nyakyusa			Kisi		
(yrs.)	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.
							Boys								
5	17	105.45	6.00	--	--	--	6	101.4	3.0	--	--	--	--	--	--
6	16	113.18	6.42	64	113.5	4.9	11	106.2	5.7	--	--	--	--	--	--
7	14	118.91	6.78	50	118.4	5.9	14	113.9	6.2	9	117.9	4.9	14	116.6	4.0
8	13	123.04	6.96	50	124.3	4.4	13	119.9	6.9	10	117.3	5.0	8	121.4	7.6
9	18	131.64	2.71	52	130.4	5.0	6	122.9	8.2	27	121.6	6.3	17	126.2	5.3
10	16	131.91	8.84	48	135.1	6.9	5	127.8	4.9	44	127.5	5.2	18	128.8	4.6
11	19	140.34	8.09	48	140.2	7.0	2	131.6	--	61	131.1	5.1	30	132.3	4.4
12	20	140.88	5.43	57	146.0	7.2	3	139.4	4.6	73	135.7	5.7	13	132.8	5.9
13	12	149.28	6.09	51	151.5	8.8	10	143.8	5.3	48	139.5	5.4	16	137.1	5.0
14	19	152.56	6.55	52	157.9	7.6	6	139.6	11.1	51	148.5	6.1	5	141.4	3.2

TABLE 6.1 : *(Contd.)*

Age	Present study			Mexican-American			Turkana			Nyakyusa			Kisi		
(yrs.)	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.
							Girls								
5	12	105.37	4.88	--	--	--	7	102.2	4.4	--	--	--	--	--	--
6.	20	111.72	6.09.	48	111.9	5.0	17	105.7	7.3	--	--	--	--	--	--
7	23	117.21	6.41	51	119.3	6.0	18	117.3	7.9	8	115.3	2.3	12	116.7	4.4
8	23	122.07	7.18	47	124.1	5.3	20	119.6	5.9	18	118.8	5.0	10	120.5	3.9
9	14	130.26	7.06	52	130.0	6.6	20	125.7	8.3	36	123.7	4.1	19	126.8	4.5
10	20	137.75	5.52	49	137.4	6.5	16	128.9	7.8	52	127.7	4.2	12	126.2	4.1
11	19	138.60	5.85	53	141.7	6.8	9	134.0	11.7	62	132.4	5.2	26	134.7	8.2
12	12	143.36	5.89	50	149.1	6.0	9	140.1	8.5	81	140.8	5.7	9	135.5	8.5
13	13	150.69	5.47	51	149.8	5.8	19	144.2	9.6	48	145.5	5.4	11	139.2	8.3
14	4	152.25	3.22	65	154.7	5.0	16	150.1	8.1	47	149.4	6.6	7	143.2	5.2

Table 6.1 : *(Contd.)*

(iii) Upper Arm Circumference (cm)

Age	Present study			Mexican-American			Turkana			Nyakyusa			Kisi		
(yrs.)	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.
							Boys								
5	17	15.76	1.03	--	--	--	6	13.7	0.4	--	--	--	--	--	--
6	16	16.19	0.95	64	16.8	1.1	11	13.5	1.5	--	--	--	--	--	--
7	14	16.31	0.76	50	17.4	1.2	14	13.7	0.9	9	16.6	1.2	14	16.8	0.7
8	13	17.14	1.13	50	18.2	1.4	13	14.3	0.8	10	16.9	1.1	8	17.2	1.5
9	18	17.19	1.00	52	19.0	2.2	6	15.1	0.9	27	17.3	1.2	17	17.7	1.2
10	16	17.52	1.42	48	19.4	1.7	5	16.3	1.4	44	18.0	1.2	18	18.2	0.9
11	19	18.68	1.53	48	20.3	2.1	2	15.4	--	61	18.3	1.0	30	18.7	1.5
12	20	18.80	1.10	57	21.2	2.1	3	16.9	0.6	73	19.0	1.2	13	18.7	1.4
13	12	20.92	1.97	51	22.6	2.3	10	17.7	1.8	48	19.5	1.2	16	19.7	1.4
14	19	20.50	1.66	52	23.2	2.4	6	16.5	1.0	51	21.0	1.4	5	19.1	1.1

TABLE 6.1 : *(Contd.)*

Age	Present study			Mexican-American			Turkana			Nyakyusa			Kisi		
(yrs.)	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.
							Girls								
5	12	15.58	0.99	–	–	–	7	13.7	1.6	–	–	–	–	–	–
6	20	16.44	1.06	48	17.0	1.4	17	13.7	1.7	–	–	–	–	–	–
7	23	16.08	0.99	51	17.7	1.3	18	14.9	1.3	8	17.5	1.2	12	17.3	1.1
8	23	16.93	1.41	47	18.0	1.6	20	14.5	1.6	18	17.4	0.9	10	17.6	1.7
9	14	16.89	1.07	52	18.6	1.8	20	15.8	1.8	36	18.1	1.0	19	18.2	1.1
10	20	18.66	1.17	49	19.8	2.3	16	16.2	0.9	52	18.5	1.0	12	18.6	0.8
11	19	18.19	1.18	53	20.5	2.4	9	16.7	2.5	62	19.0	1.1	26	19.8	1.5
12	12	19.67	2.01	50	21.9	2.7	9	17.8	1.6	81	20.1	1.4	9	20.3	1.7
13	13	21.54	1.66	51	22.0	2.5	19	18.5	1.9	48	21.2	1.7	11	20.3	1.9
14	4	21.40	1.64	65	23.5	3.1	16	19.2	1.9	47	22.5	2.1	7	21.5	1.2

TABLE 6.1 : *(Contd.)*

(iv) Triceps skinfold (mm)

Age	Present study			Mexican-American			Turkana			Nyakyusa			Kisi		
(yrs.)	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.
							Boys								
5	17	8.29	2.14	--	--	--	6	5.0	0.9	--	--	--	--	--	--
6	16	7.25	1.84	64	8.0	1.7	11	4.0	1.3	--	--	--	--	--	--
7	14	6.79	1.67	50	7.8	1.4	14	4.1	1.6	9	5.7	0.8	14	6.1	0.5
8	13	7.63	1.32	50	8.6	2.4	13	4.3	1.4	10	5.6	1.3	8	5.7	1.0
9	18	7.00	2.14	52	9.9	4.5	6	4.2	0.8	27	5.9	1.1	17	5.5	1.0
10	16	6.50	2.31	48	9.5	3.4	5	5.8	1.7	44	6.3	1.4	18	5.8	1.0
11	19	7.89	2.18	48	10.5	3.6	2	4.5	--	61	5.9	1.3	30	5.6	1.4
12	20	8.60	3.33	57	10.7	4.0	3	6.2	1.6	73	6.4	1.5	13	5.8	1.0
13	12	8.83	1.27	51	9.7	5.0	10	5.8	1.9	48	5.9	1.4	16	5.6	1.4
14	19	8.58	1.74	52	9.1	4.1	6	5.5	2.6	51	6.5	1.8	5	5.3	0.7

TABLE 6.1 : *(Contd.)*

Age	Present study			Mexican-American			Turkana			Nyakyusa			Kisi		
(yrs.)	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.
							Girls								
5	12	8.42	2.02	–	–	–	7	5.3	2.3	–	–	–	–	–	–
6	20	8.60	1.64	48	10.0	2.7	17	5.0	1.3	–	–	–	–	–	–
7	23	7.43	1.34	51	9.9	2.1	18	5.3	1.6	8	8.0	1.1	12	6.8	1.3
8	23	8.35	1.67	47	9.8	2.6	20	4.4	1.6	18	7.1	1.6	10	6.9	1.6
9	14	7.36	1.91	52	11.2	3.9	20	5.3	1.7	36	6.9	1.4	19	7.4	1.6
10	20	9.50	1.50	49	12.5	4.7	16	6.2	1.8	52	7.1	1.5	12	6.7	1.4
11	19	9.74	2.64	53	13.6	6.5	9	5.7	2.5	62	7.7	1.8	26	7.2	1.9
12	12	11.58	3.29	50	14.0	5.3	9	6.4	2.0	81	7.8	2.0	9	6.5	1.6
13	13	13.77	2.80	51	15.0	5.0	19	7.2	3.2	48	8.0	1.9	11	7.0	2.0
14	4	12.50	2.08	65	17.2	6.0	16	7.6	3.4	47	10.2	3.4	7	8.7	3.0

Table 6.2 : *Mean values for sitting height for Mexican-American^a, Nyakyusa^b and Kisi^b children and for head circumference for Nyakyusa^a and Kisi^b children with present study children*

(i) Sitting Height (cm)

Age	Present Study			Mexican-American^a			Nyakyusa^b			Kisi^b		
(yrs.)	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.
						Boys						
5	17	56.85	2.50	116	62.8	3.2	-	--	-	-	-	-
6	16	60.37	2.55	110	65.2	3.0	-	-	-	-	-	-
7	14	61.61	3.11	109	67.5	3.2	9	59.2	1.2	14	58.8	2.4
8	13	63.99	3.46	107	70.0	2.6	10	60.4	2.3	8	61.0	4.2
9	18	65.21	2.48	103	72.2	3.3	27	61.7	2.9	17	62.1	2.7
10	16	65.86	3.45	90	74.1	3.7	44	63.6	2.3	18	62.7	2.6
11	19	69.92	3.52	120	77.3	3.9	61	65.1	2.3	30	63.9	2.4
12	20	68.86	2.89	114	79.2	4.0	73	66.4	2.5	13	64.6	2.7
13	12	73.54	3.46	103	83.5	4.1	48	67.9	2.6	16	65.5	3.2
14	19	73.38	4.40	91	85.9	3.9	51	71.8	3.3	5	66.9	3.0

TABLE 6.2 : *(Contd.)*

Age	Present Study			Mexican-American[a]			Nyakyusa[b]			Kisi[b]		
(yrs.)	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.
						Girls						
5	12	56.46	2.61	112	62.1	2.8	--	--	--	--	--	--
6	20	59.92	2.32	116	64.7	2.7	--	--	--	--	---	-
7	23	61.02	2.26	96	66.6	3.0	8	59.0	1.2	12	59.8	1.8
8	23	63.05	3.08	112	69.2	3.5	18	60.6	2.4	10	60.8	2.1
9	14	65.21	3.22	115	71.9	3.5	36	62.7	2.2	19	62.6	2.3
10	20	68.36	2.58	98	75.5	3.9	52	64.0	2.2	12	63.2	1.9
11	19	69.35	2.89	120	77.2	4.7	62	65.5	2.4	26	66.6	3.4
12	12	70.43	2.96	104	80.9	3.0	81	68.9	2.8	9	66.9	4.0
13	13	74.18	3.54	90	83.1	3.3	48	71.2	2.9	11	67.2	4.5
14	4	75.52	2.67	80	83.8	2.7	47	73.4	3.4	7	70.2	3.2

[a] Martorell, *et al.*, 1988
[b] Hautvast, 1971b

Table 6.2 : *(Contd.)*

(ii) Head Circumference (cm)

Age	Present study			Nyakyusa			Kisi		
(yrs.)	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.
					Boys				
5	17	52.26	1.4	--	--	--	--	--	--
6	16	52.09	1.6	--	--	--	--	--	--
7	14	52.39	1.3	9	51.8	1.2	14	50.4	1.7
8	13	52.53	1.2	10	52.3	1.3	8	50.3	1.8
9	18	53.22	1.4	27	52.6	1.4	17	52.2	2.1
10	16	53.18	2.2	44	53.2	1.2	18	52.2	1.6
11	19	53.59	1.3	61	53.0	1.5	30	52.3	1.4
12	20	53.44	1.3	73	53.6	1.1	13	52.1	0.8
13	12	54.23	1.5	48	53.9	1.5	16	52.1	1.7
14	19	54.15	1.3	51	54.5	1.1	5	54.0	3.5

TABLE 6.2 : *(Contd.)*

Age	Present study			Nyakyusa			Kisi		
(yrs.)	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.
					Girls				
5	12	50.53	1.3	--	--	--	--	--	--
6	20	51.26	1.0	--	--	--	--	--	--
7	23	51.13	1.1	8	50.8	1.6	12	50.4	1.4
8	23	51.44	1.3	18	51.1	1.9	10	51.3	1.6
9	14	51.58	0.9	36	51.7	1.4	19	50.4	1.7
10	20	52.36	1.2	52	52.3	1.3	12	51.0	1.6
11	19	52.37	1.0	62	52.2	1.2	26	51.1	2.1
12	12	52.58	1.6	81	53.0	1.3	9	52.0	2.4
13	13	52.95	1.2	48	53.5	1.3	11	52.7	1.5
14	4	52.35	2.4	47	54.0	1.4	7	53.2	1.5

TABLE 6.3 : *Derived leg lengths (cm) of Kisii (Kenya), Mexican-American, Nyakyusa and Kisi (Tanzania) children*

Age (yrs.)	Boys				Girls			
	Kisii	Mexican-American[a]	Nyakyusa[b]	Kisii[b]	Kisii	Mexican-American[a]	Nyakyusa[b]	Kisi[b]
5	48.60	48.7	--	--	48.91	48.7	--	--
6	52.81	52.3	--	--	51.80	52.9	--	--
7	57.30	55.5	58.7	57.8	56.19	55.4	56.3	56.9
8	59.05	59.1	56.9	60.4	59.02	58.5	58.2	59.7
9	66.43	61.6	59.9	64.1	65.05	63.5	61.0	64.2
10	66.05	65.4	63.9	66.1	69.39	66.0	63.7	63.0
11	70.42	69.0	66.0	68.4	69.25	69.3	66.9	68.1
12	72.02	72.8	69.3	68.2	72.93	71.9	71.9	68.6
13	75.74	76.4	71.6	71.6	76.51	73.5	74.3	72.0
14	79.18	79.5	76.7	74.5	76.73	73.0	76.0	73.0

[a] Martorell *et al*., 1988.

[b] Hautvast, 1971b.

children, Kenya (Little *et al.*, 1983), and the Nyakyusa and Kisi children from Tanzania (Hautvast, 1971b). Comparative data are given in Tables 6.1 to 6.3. Average weight/height indices are also given in Table 6.4 and illustrated in Fig. 6.10.

Kisii children (present study) fall consistently below the NCHS 50th percentile curves for both weight and height and are well above the curves for the Turkana from north-western Kenya, and Nyakyusa and Kisi children from Tanzania. The weight curves in comparison to the Mexican-American curves run lower but as age increases the differences become larger. These differences are more pronounced after the 10th year. However, for height curves the two groups (Mexican-American and Kisii children) have curves which run close to each other. Kisii (Kenya) boys are less than a year to 2 years behind the NCHS male 50th percentiles from ages 7 to 14 years for height. The same general trend holds true for girls' height. The growth pattern for height and weight for other three East African children, namely, Bantu speaking Kisi and Nyakyusa of Tanzania and paranilotic Turkana pastoral children from Kenya, is similar to that for Kenyan Kisii children, but the Kenyan Kisii children are both taller and heavier throughout the age range (Figs. 6.3 and 6.9).

The height growth pattern of the Kisii and the Mexican-American children are similar. But Mexican-Americans are heavier for the same stature and they have longer trunks and shorter legs. A comparison between the sitting heights of Kisii children and Mexican-American children (Fig. 6.4a and c) reveal that throughout the age range considered the Mexican-American children have larger sitting height values. On the other hand, a comparison between the Kisii and

TABLE 6.4 : *Weight/Height indices of the Kisii, Mexican-American, Turkana, Nyakyusa and Kisi children compared with NCHS (1977) values.*

Age yrs.	$\frac{\text{Wt.}}{\text{ht.}} \times 100$					
	Kisii	Mexican-American	Turkana	Nyakyusa	Kisi (Tanzania)	50th NCHS
			Boys			
5	15.6	--	13.2	--	--	17.0
6	16.9	17.4	14.2	--	--	17.8
7	17.6	18.7	15.5	18.2	17.3	18.8
8	19.1	20.1	16.1	18.8	17.7	19.9
9	19.5	22.2	16.4	20.1	18.8	21.3
10	20.2	22.9	18.2	21.2	19.5	22.9
11	22.8	24.5	18.2	21.9	20.6	24.6
12	22.8	26.8	19.3	23.2	20.5	26.6
13	24.9	29.2	20.8	24.3	22.8	28.7
14	25.9	30.7	20.1	27.1	21.4	31.1
			Girls			
5	14.8	--	13.1	--	--	16.3
6	16.7	17.4	13.6	--	--	17.0
7	16.8	18.7	15.6	19.1	16.8	18.1
8	18.7	19.1	15.4	18.7	17.4	19.7
9	18.2	21.2	17.3	19.6	18.5	21.5
10	21.0	24.1	18.0	20.5	19.1	23.5
11	20.7	25.8	18.2	21.1	21.2	25.5
12	23.9	29.0	23.9	23.9	21.7	27.4
13	26.8	29.9	20.6	26.3	21.5	29.3
14	26.0	32.5	21.9	28.6	23.7	31.4

Mexican-American leg lengths (Fig. 6.5) reveals that the Kisii children throughout the age range have got longer legs than the Mexican-Americans. Similarly, a comparison between their triceps skinfold measurements (Fig. 6.6b & d) reveals that Mexican-Americans have larger fat deposits than the Kisii children. The evidently larger trunks and fat deposits in the Mexican-Americans make them heavier than Kisii children. The longer leg lengths of the Kisii children in comparison to Mexican-American children, on the other hand, tends to make them (Kisii children) tall enough for their heights to be comparable to those of Mexican-Americans.

As would be expected from the foregoing, weight/height ratios of Kisii children run lower to those for both the NCHS 50th percentile and the Mexican-Americans. These differences are illustrated in Fig. 6.10. Kisii children are more linear in physique as compared to Mexican-Americans children. Initially, this difference is small but with the increase in age the gap between the two groups widens. This is also reflected in Figs. 6.3 and 6.4. While the height curves are nearly the same throughout, the differences in their weight curves increase with age.

The Turkana pastoralists in comparison with the Kisii children are both shorter and lighter. Fig. 6.10 reveals that of the six groups used for comparisons, Turkana children are of leanest physiques. The Turkana inhabit a semi-arid region. They are constantly on the move because of environmental stresses. Although they suffer from seasonal nutritional stresses (Little *et al.*, 1983) their lean physique is likely not to be solely attributable to limited food intake but is also under some degree of genetic control (Little, 1980 and Roberts, 1960). The lean physique they exhibit perhaps accounts for their

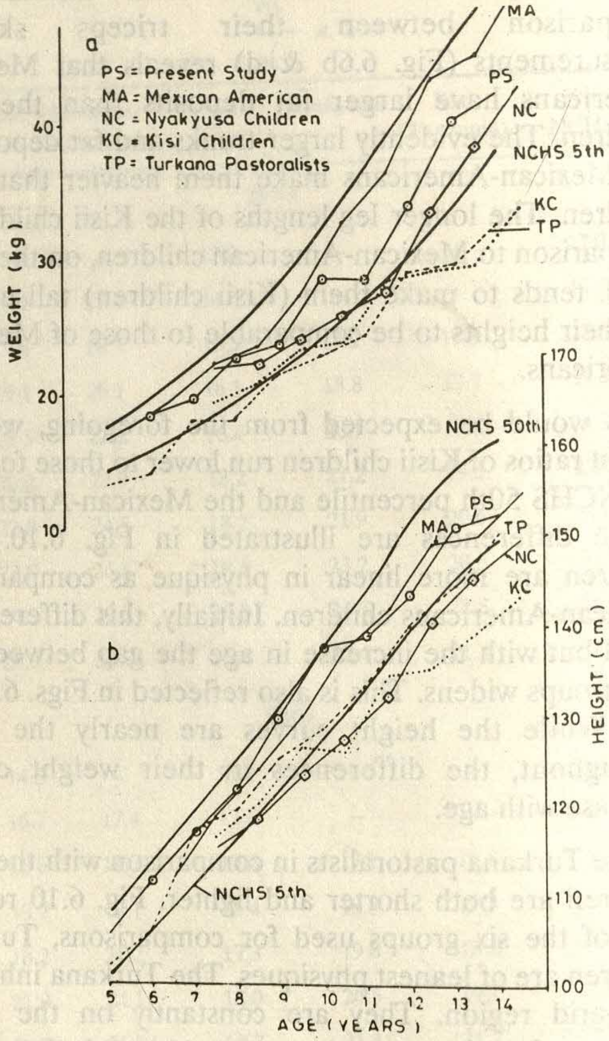

Fig. 6.3 : Weight and height distance curves for Kisii, Mexican-American, Turkana, Nyakyusa and Kisi girls.

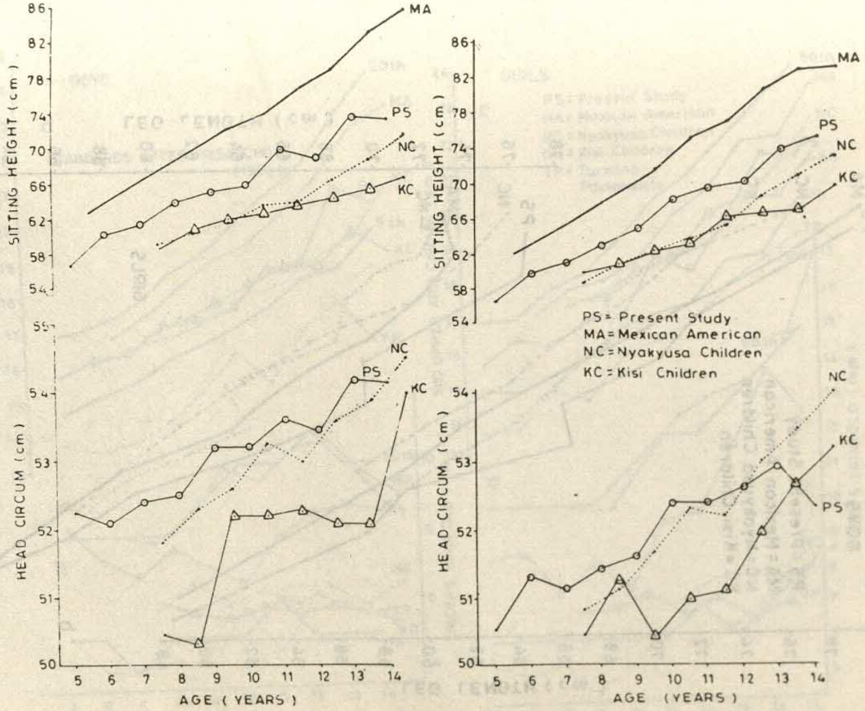

Fig. 6.4 : Distance curves for sitting height and head circumference of Kisii compared with other groups.

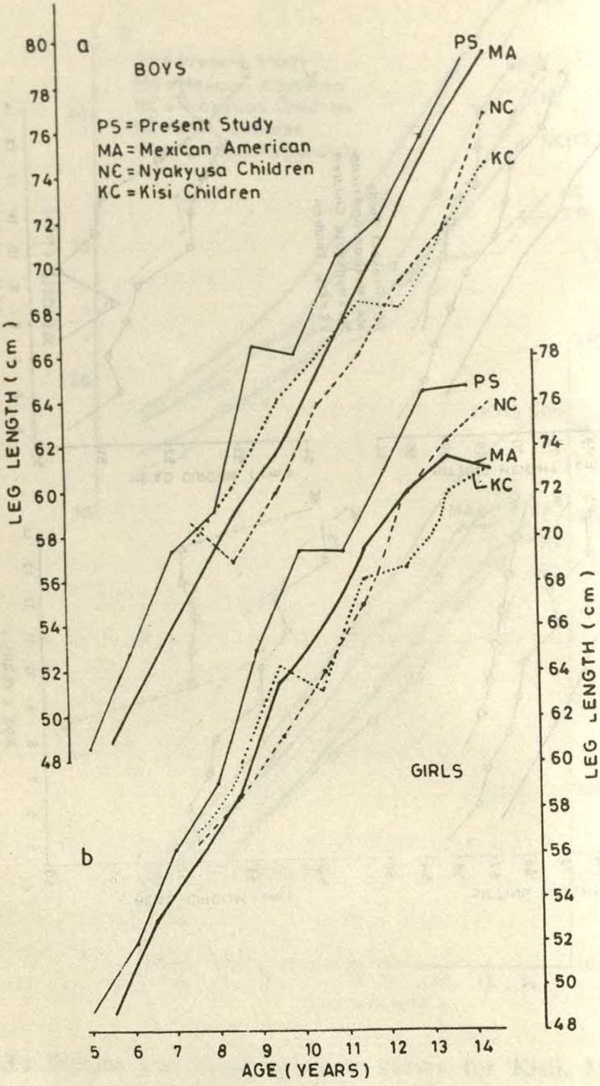

Fig. 6.5 : Leg length distance curves for Kisii, Mexican-American, Nyakyusa and Kisi children.

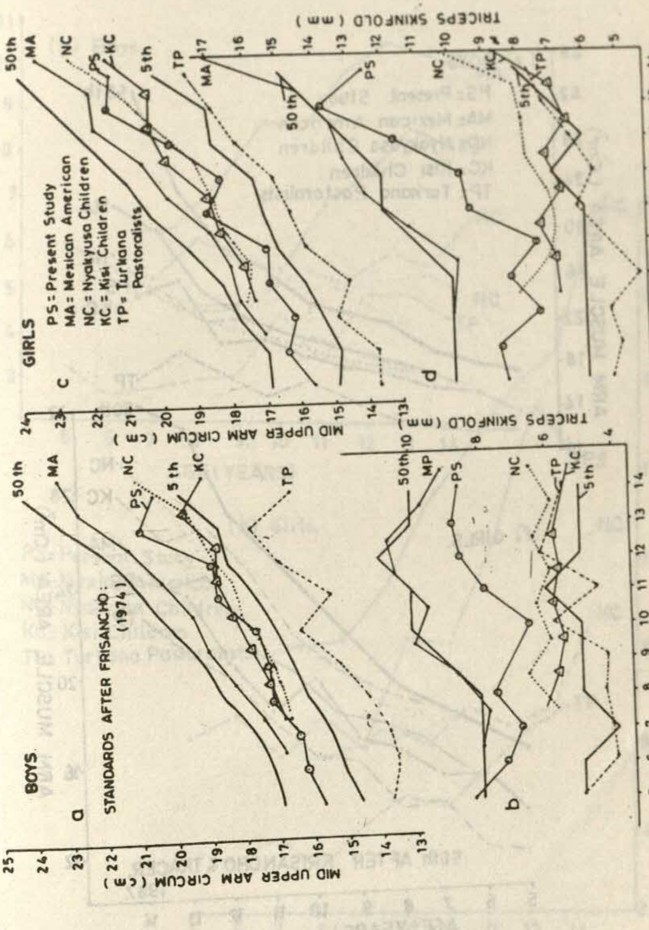

Fig. 6.6 : Distance curves for upper arm circumference and triceps skinfold of Kisii children compared with other groups.

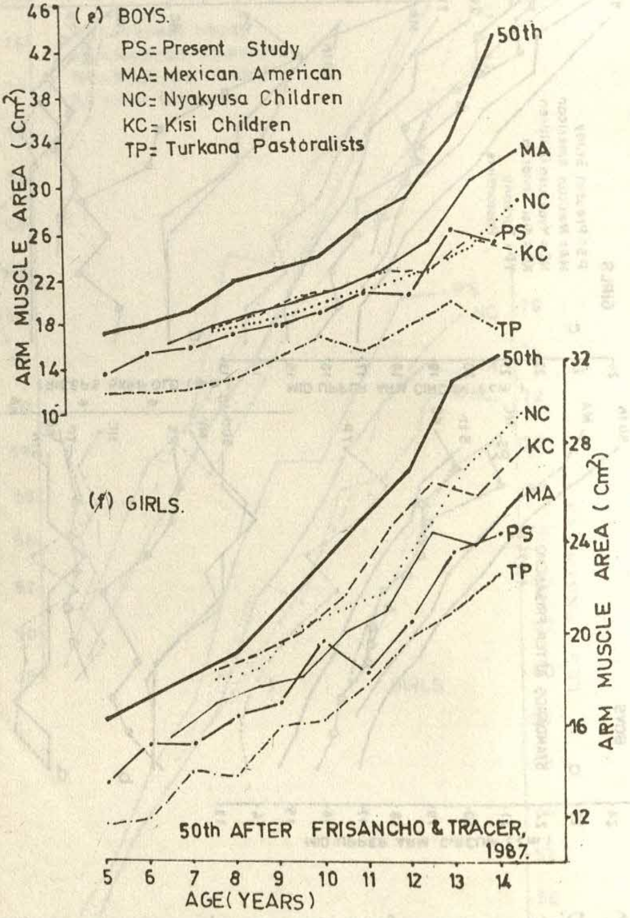

Fig. 6.7 : Upper arm muscle areas of Kisii boys and girls compared with other groups.

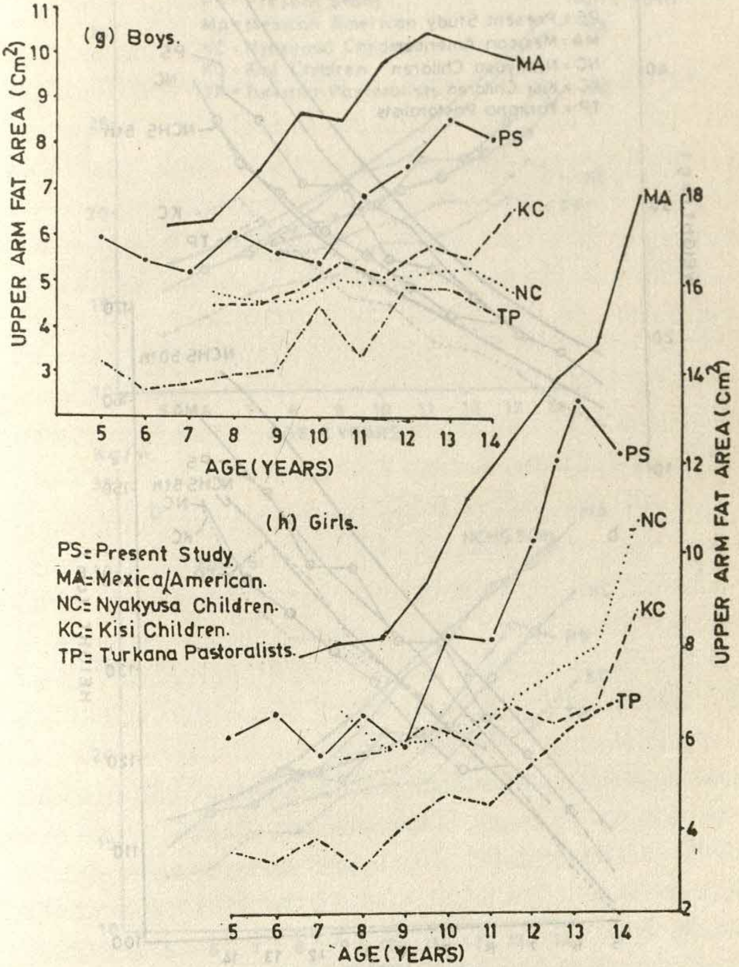

Fig. 6.8 : Distance curve for upper arm fat areas (cm^2) of Kisii children compared with other groups.

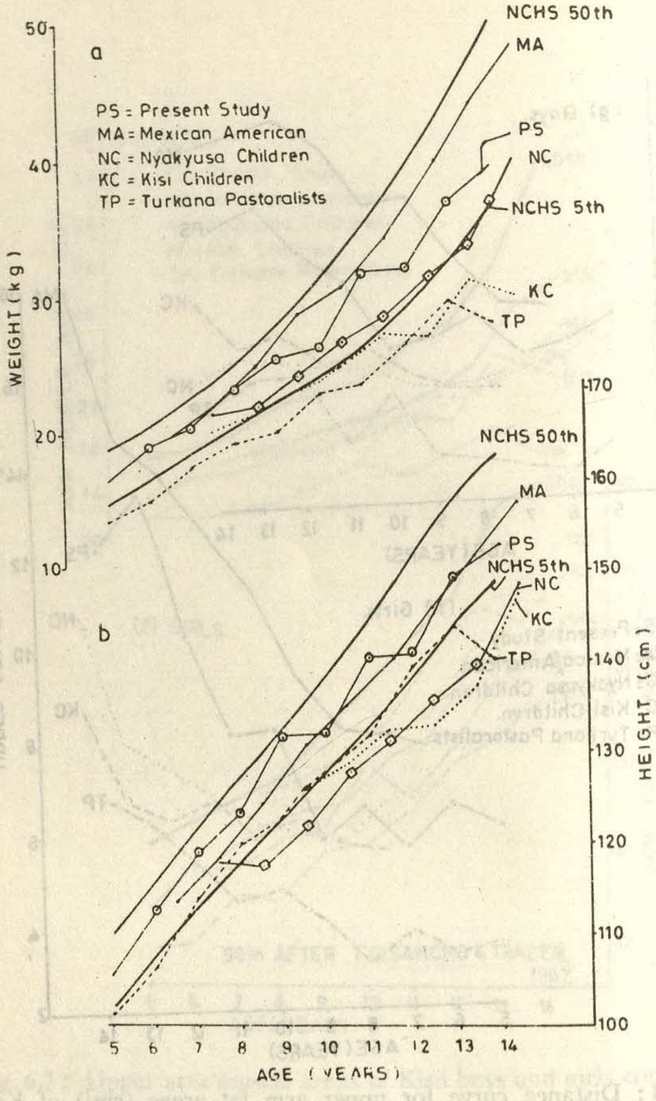

Fig. 6.9 : Weight and height distance curves for Kisii, Mexican-American, Turkana, Nyakyusa and Kisi boys.

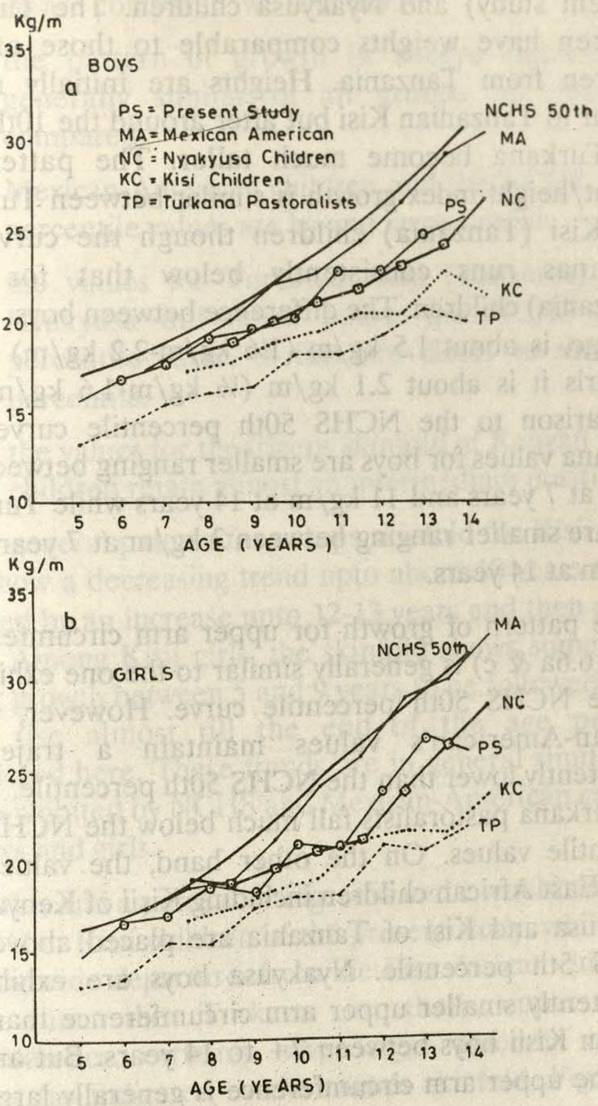

Fig. 6.10 : Weight/height indices for Kisii children compared with NCHS 50th percentile, Mexican-American, Turkana, Nyakyusa and Kisi children.

smaller body weights in comparison to both the Kisii (present study) and Nyakyusa children. The Turkana children have weights comparable to those of Kisi children from Tanzania. Heights are initially nearly similar to Tanzanian Kisi but after around the 10th year the Turkana become much taller. The pattern of weight/height index growth is similar between Turkana and Kisi (Tanzania) children though the curve for Turkanas runs consistently below that for Kisi (Tanzania) children. The difference between boys, on an average, is about 1.5 kg/m (1½ kg/m-2.2 kg/m) while for girls it is about 2.1 kg/m (½ kg/m-1.6 kg/m). In comparison to the NCHS 50th percentile curve, the Turkana values for boys are smaller ranging between 3.5 kg/m at 7 years and 11 kg/m at 14 years while Turkana girls are smaller ranging between 3 kg/m at 7 years and 9 kg/m at 14 years.

The pattern of growth for upper arm circumference (Figs. 6.6a & c) is generally similar to the one exhibited by the NCHS 50th percentile curve. However, while Mexian-American's values maintain a trajectory consistently lower than the NCHS 50th percentile, those for Turkana pastoralists fall much below the NCHS 5th percentile values. On the other hand, the values for other East African children including Kisii of Kenya and Nyakyusa and Kisi of Tanzania are placed above the NCHS 5th percentile. Nyakyusa boys are exhibiting consistently smaller upper arm circumference than the Kenyan Kisii boys between 7+ to 14 years. But among girls the upper arm circumference is generally larger in Nyakyusa than Kenyan Kisii upto about 12 years. Thereafter, Kisii girls tend to overtake Nyakyusa girls. Position with respect to Kisi children from Tanzania is somewhat similar to that between Kisii and Nyakyusa boys and girls.

Now, when average values for triceps skinfold (Fig. 6.6b & d) are compared, we find that--

(*i*) the pattern of growth in triceps skinfold is generally similar in all groups of children compared.

(*ii*) Mexican-American children and the NCHS 50th percentile values are by and large similar.

(*iii*) the values for Turkanas, Kisi (Tanzania) and Nyakyusa fall much below the NCHS 50th percentile curve, in fact are closer to the 5th percentile.

(*iv*) the values for the triceps skinfold of Kenyan Kisii children retain almost an intermediate position.

The general pattern for triceps skinfold for Kisii boys is to show a decreasing trend upto about 10 years to be followed by an increase upto 12-13 years and then a fall again. Among Kisii girls, the skinfold shows somewhat slower growth between 5 and 9 years to be followed by a steep rise almost till the end of the age period considered here. These trends are in general similar to those exhibited by NCHS and Mexican-American curves for boys and girls.

All this and a perusal of Fig. 6.6a and c would tend to reveal that Kisii children of the present study, while not showing wide departures from the East African children other than the Turkana in their upper arm circumference, certainly have larger amounts of fat content (as indicated by the triceps skinfold, Fig. 6.6b and d).

This is also borne out by the calculation of upper arm muscle area (Frisancho and Tracer, 1987) and upper arm fat area (total upper arm area minus upper arm muscle area). Total upper arm area (TUA) was computed from the mean values of upper arm circumference (C) and triceps skinfold (Ts) using the following equation (Frisancho and Tracer, 1987) :

$$\text{TUA (cm}^2\text{)} = \frac{(C)^2}{(4 \times 3.1416)}$$

For upper arm muscle area (UMA) the following formula was used (Frisancho and Tracer, 1987) :

$$\text{UMA (cm}^2\text{)} = \frac{(C - Ts \times 3.1416)^2}{(4 \times 3.1416)}$$

The upper arm fat area (UFA) was obtained from the following equation :

$$\text{UFA (cm}^2\text{)} = \text{TUA (Cm}^2\text{)} - \text{UMA (Cm}^2\text{)}$$

All these variables have been computed using the mean values for various population groups compared, and the comparative results are presented in Tables 5 and 6.6 and illustrated in Figs. 6.7a, b and 6.8a, b.

A perusal of these Tables and Figures reveals that :

(*i*) In both Kisii boys and girls, UMA and UFA are less than US norms (Frisancho, 1981; Frisancho and Tracer, 1987) and Mexican-Americans (Zavaleta and Malina, 1980).

(*ii*) Turkana boys and girls hold the lowest position in the distribution of values for the populations compared here for both UMA and UFA.

(*iii*) In both Kisii boys and girls (Kenya), UMA tends to be less than that in Nyakyusa and Kisi (Tanzania) mean values.

(*iv*) In contrast to above, the Kisii boys and girls have considerably larger values for their UFA than those in Nyakyusa and Kisi of Tanzania.

In summary, the comprehensive picture of the nutritional status of Kisii children, 5 to 14 years old, *vis-a-vis* other East African children, is as follows :

(*i*) Kisii are the tallest and heaviest age-wise among the four East African population groups.

(*ii*) As revealed by weight-for-height curves (Figs. 6.11 and 6.12), Nyakyusa children are heavier for the same height irrespective of age than the Kisii (Kenya), Kisi (Tanzania) and the Turkana children. In comparison to Kisi girls of Tanzania, Kisii girls from Kenya tend to be similar in weight-for-height upto about 130 cm; but are lighter for the same height between 130 cm to 142.5 cm. Among boys, the curves are almost similar in pattern and relative position with little major departures from each other.

(*iii*) Weight/height indices calculated according to age reveal that Nyakyusa and Kisii boys and girls are comparable to each other. The values for Kisi boys and girls are less than those for both Nyakyusa and Kisii children. Turkana boys and girls hold the lower-most position

(*iv*) Age-for-age, Kisii boys and girls have smaller upper arm muscle area (UMA) than both Nyakyusa and Kisi of Tanzania. The differences are, however, less pronounced among boys than girls. Turkana children have the lowest mean values for UMA among the four population groups from East Africa.

TABLE 6.5 : *Upper Arm Muscle areas (cm²) calculated from mean values*

Age yrs.	Present study	Mexican-American	Turkana	Nyakyusa	Kisi	50th[a] percentile NCHS
			Males			
5	13.77	--	11.70	--	--	17
6	15.40	16.24	11.92	--	--	18
7	15.99	17.78	12.26	17.45	17.63	19
8	17.29	19.11	13.34	18.24	18.90	22
9	17.88	20.08	15.11	18.99	20.30	23
10	19.06	21.44	16.68	20.43	21.35	24
11	20.88	23.00	15.57	21.52	22.84	27
12	20.61	25.31	17.79	22.97	22.67	29
13	26.19	30.41	20.06	24.78	25.61	34
14	25.22	32.91	17.37	28.60	24.19	43
			Females			
5	13.31	--	11.53	--	--	16
6	15.01	15.28	11.71	--	--	17
7	15.03	16.93	13.94	17.87	18.30	18
8	16.28	17.71	13.69	18.31	18.95	19
9	16.90	18.09	15.90	20.20	20.06	21
10	19.55	20.04	16.16	21.06	21.65	23
11	18.21	20.95	17.69	21.88	24.48	25
12	20.45	24.37	19.84	24.79	26.53	27
13	23.57	23.77	20.98	27.79	26.07	31
14	24.29	26.05	22.49	29.63	28.03	32

[a] Frisancho and Tracer, 1987

TABLE 6.6 : *Upper arm fat area** (cm^2) *calculated from mean values*

Age yrs.	Present study	Mexican-American	Turkana	Nyakyusa	Kisi
			Boys		
5	6.0	--	3.2	--	--
6	5.5	6.2	2.6	--	--
7	5.2	6.3	2.7	4.5	4.8
8	6.1	7.3	2.9	4.5	4.6
9	5.6	8.7	3.0	4.8	4.6
10	5.4	8.5	4.5	5.4	5.0
11	6.9	9.8	3.3	5.1	5.0
12	7.5	10.5	4.9	5.8	5.2
13	8.6	10.2	4.9	5.5	5.3
14	8.2	9.9	4.3	6.5	4.8
			Girls		
5	6.0	--	3.4	--	--
6	6.5	7.7	3.2	--	--
7	5.6	8.0	3.7	6.5	5.5
8	6.5	8.1	3.0	5.8	5.7
9	5.8	9.4	4.0	5.9	6.3
10	8.2	11.2	4.7	6.2	5.9
11	8.1	12.5	4.5	6.8	6.7
12	10.3	13.8	5.4	7.4	6.3
13	13.4	14.7	6.3	8.0	6.7
14	2.2	17.9	6.8	10.7	8.8

* Obtained as the difference between Total Upper Area (TUA) and the Upper Arm Muscle Area (UMA) *i.e.,* – UFA (cm^2) = TUA (cm^2)– UMA (cm^2).

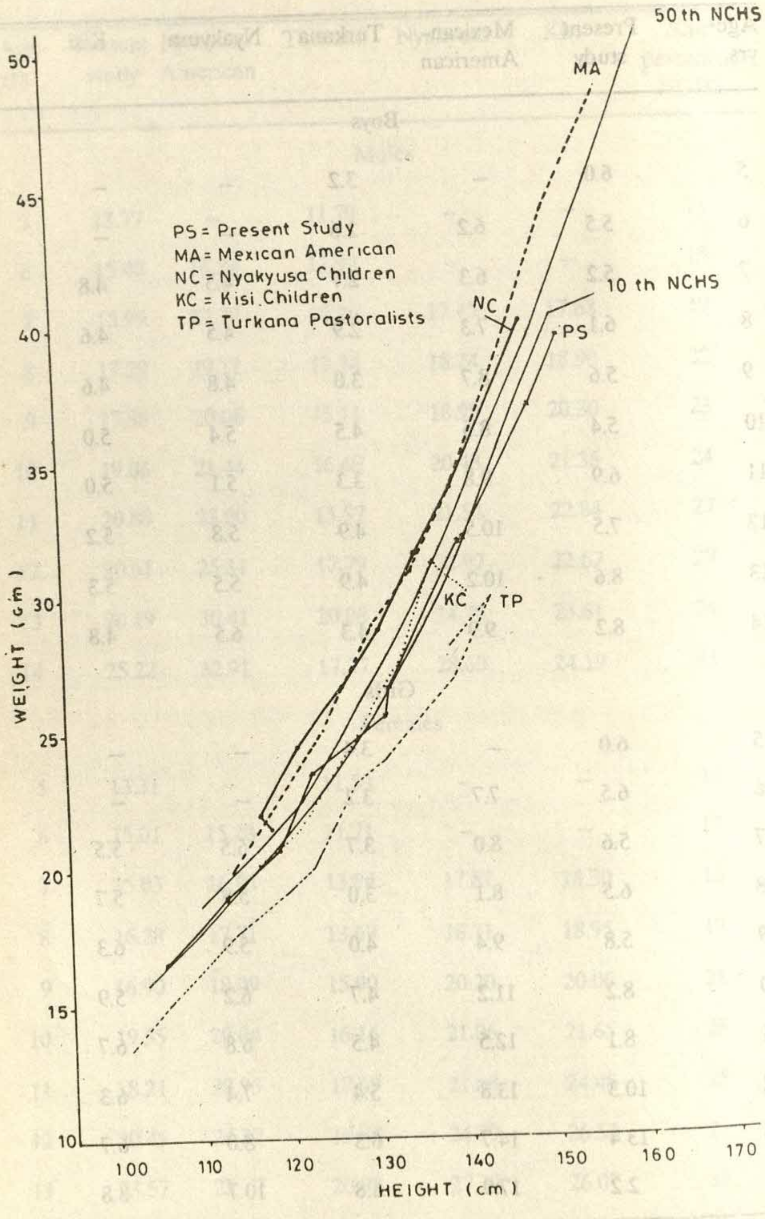

Fig. 6.11 : Weight by height for Kisii boys compared with other groups.

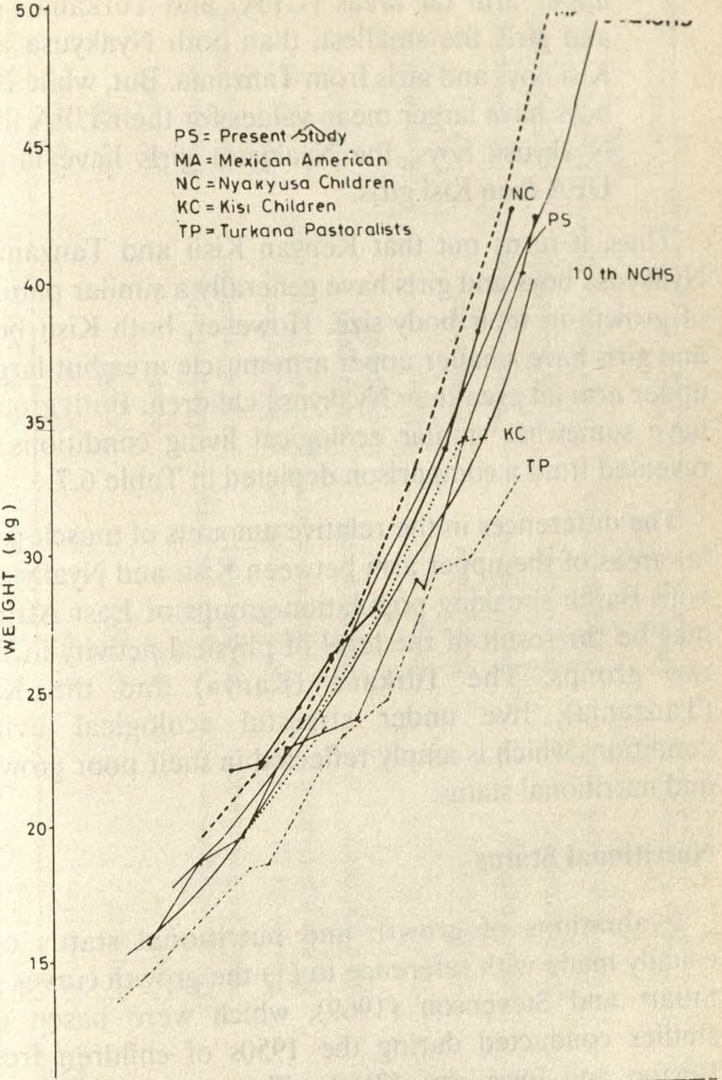

Fig. 6.12 : Weight by height for Kisii girls compared with other groups.

(*v*) Age-for-age, Kisii boys and girls have the largest upper arm fat areas (UFA) and Turkana boys and girls the smallest, than both Nyakyusa and Kisi boys and girls from Tanzania. But, while Kisi boys have larger mean values for their UFA than Nyakyusa boys, the Nyakyusa girls have larger UFA than Kisi girls.

Thus, it turns out that Kenyan Kisii and Tanzanian Nyakyusa boys and girls have generally a similar pattern of growth in their body size. However, both Kisii boys and girls have smaller upper arm muscle area but larger upper arm fat area than Nyakyusa children. Both groups have somewhat similar ecological living conditions as revealed from a comparison depicted in Table 6.7.

The differences in the relative amounts of muscle and fat areas of the upper arm between Kisii and Nyakyusa, both Bantu speaking population groups of East Africa, may be the result of the level of physical activity in the two groups. The Turkana (Kanya) and the Kisi (Tanzania), live under stressful ecological living conditions which is amply reflected in their poor growth and nutritional status.

Nutritional Status

Evaluations of growth and nutritional status are usually made with reference to (1) the growth curves of Stuart and Stevenson (1969), which were based on studies conducted during the 1950s of children from Boston and Iowa city, (2) the Tanner growth curves, based on investigations of British children (Tanner *et al.*, 1965), (3) the Fels Research Institute growth curves (Hamill *et al.*, 1977), based on studies of a longitudinal sample of 867 children evaluated during the period of

TABLE 6.7 : *Differences in ecological living conditions between the Kisii, Nyakyusa, Kisi and Turkana children*

	Kisii (Kenya)	Kisi (Tanzania)	Nyakyusa (Tanzania)	Turkana (Kenya)
Altitude (above sea level)	1219-2133 m	520 m	1500 m	600-800m
Rainfall (mm/yr)	1600-2000	± 1000	± 2500	100-500
Climate	Cool	hot	cools	hot & dry
Food	Mainly carbohydrates, many vegetables, less proteins.	Monotonous, many proteins (fish)	Much variation, mainly vegetables.	Less variation mainly proteinous
Diseases	Western like *e.g.* Malaria hypoendemic	obvious tropical, *e.g.* malaria holoendemic	Western like *e.g.* malaria hypo-endemic	N.A.*
Medical Institutions/ Health Care	good equipment	poor equipment	rather good equipment	minimal
Ethnic group	Bantu	Bantu	Bantu	Poranibotic
Marriage rule	Endogamous	Endogamous	Endogamous	N.A.*
Language	Bantu speaking	(not related to	Nilotic language)	Nilotic language
Position	easily accessible	very isolated	easily accessible	largely inaccessible
Economics	Cash crops, coffee, tea	fishing and pottery	Cash crops, coffee, tea	Livestock, coffee, goats, etc.
Land holding	Private owned; small	State owned	land	Nomadic

* N.A. = Not available.

1929-1975, and (4) the National Centre for Health Statistics (NCHS) growth curves, which were derived from a combined sample of data from the NCHS's Health Examination Survey (HES), conducted during 1963-1965 and 1970-1974, and data from the Fels Research Institute (Hamill *et al.*, 1977). A common feature of all these standards is that they provide information only on height and weight (Frisancho and Tracer, 1987). These standards have been used by various researchers to determine the extent to which children are either normal, advanced, or delayed in their growth for age. Furthermore, these standards are used to find out whether children are either obese or undernourished for their height (Waterlow *et al.*, 1977). Although this approach has the advantage of being based on easily obtainable measurements, it is ineffective for accurately distinguishing the truly malnourished child from the simply under-weight child (Frisancho and Tracer, 1987). PEM is characterised by a decrease in both fat and muscle tissue.

Usually a child suffering from PEM will have a low weight for height, but a tall and normally lean child can also have a low weight for height. Likewise, because obesity is characterised by excess fat, an obese child usually has a high weight for height, but a muscular and large framed child can also have a high weight for height. That is to say that excess weight doesn't necessarily imply excess fat nor does being underweight relate to PEM. For this reason, assessment of nutritional status based only on weight and height, especially when the degree of underweight is moderate, is bound to be ineffective in distinguishing the truly wasted (*i.e.*, low fat and muscle) from the normally low weight child and truly obese from the normally heavy child.

To circumvent this problem measurements of skinfold thickness and limb muscle size have also been used to assess the nutritional status of children (Bengoa *et al.*, 1959; Jelliffe, 1966). The degree of outer fatness and the size of the muscle mass indirectly indicate the calorie and protein reserves in the body (Frisancho and Garn, 1971). Increased fatness and hence calorie reserves can result either from a high calorie intake or low energy expenditures. Thus, one would expect that fatter children, for their age, are both taller and developmentally more advanced than average children. Clinical investigations reveal that obese children are indeed taller and more advanced in maturity (Peckos, 1953; Wolff, 1955; and Lloyd *et al.*, 1961).

(*i*) *Degree of Malnutrition*

Using three methods, namely weight deficit, height deficit, and the triceps skinfold method, the school age children have been classified into four grades of nutritional status. Using weight deficit, a picture of the current nutritional status is seen while height deficit gives the past nutritional status of the individual/ population. Body fat, on the other hand, varies considerably with nutritional status; the measurement of the subcutaneous fatfold provides an estimate of caloric reserves available to the individual (Gurney and Jelliffe, 1973; and Malina *et al.*, 1974).

On the basis of these three methods (Tables 5.16, 5.18 and 5.19) a number of children were found to suffer from marginal malnutrition. Girls, however, are seen to be much better with regard to their nutritional status than are boys.

Comparisons of the three methods used for classifying the children into various grades of nutritional status are given in Table 6.8.

TABLE 6.8 : *Comparison of the various methods used to assess nutritional status*

Method	Normal %			Malnourished (Total) %		
	Boys	Girls	Total	Boys	Girls	Total
Weight deficit	33.0	36.0	34.5	67.0	64.0	65.5
Height deficit	54.0	64.0	59.0	46.0	36.0	41.0
TSF Method	45.0	47.0	46.0	55.0	53.0	54.0

A perusal of this table indicates that there are more children suffering from current nutritional stresses. However, on the basis of the height deficit nutritional supplies may be described as being above average. The data presented here was collected in the months of March/April, 1988. January and February are the driest months in the area, and rains set in from March to May with the result that during January and February and early part of the rainy season the population is subjected to nutritional stresses. This is reflected in their current nutritional status based on weight deficit and the reduced caloric reserves based on the skinfold method.

(*ii*) *Nutritional Deficiency Signs*

Malnutrition is an important problem in both developing and developed countries, important in the sense that it demands attention from planners, from those concerned with community health and from other government and non-governmental agencies.

Nutritional intervention programmes can be easily planned if the problematic or target areas have been identified. Methods like the fortification of various food stuffs with vitamins or minerals or the iodization of salt are done on the basis of "nutritional deficiency diseases" data collected.

A perusal of Table 5.20, reveals that vitamin A deficiency occurs in 16.35% of the children. Highest incidences are seen in the 12 year old (31.3%), 11 year old (23.79%) and 10 year old (22.2%) children.

Vitamin B deficiency rather than being a simple deficiency disease is in itself complex. It contains many separate factors which vary greatly in their chemical composition and function. However, chiefly they are an important constituent of enzymes. Their absence will thus cause great imbalance in enzyme activities bringing limitations, which may be severe, in the utilization of certain foods. These limitations are then manifested in various forms such as cheilosis, dermatosis, pellagrous dermatosis and atrophic lingual papaillae. Only 3.4% (Table 5.20) of the children were found to be vitamin B complex deficient.

Vitamin C deficiency manifests itself through spongy and bleeding gums. 11.73% of the children were classified as having vitamin C deficiency. Vitamin D deficiency occurs with a prevalence of 3.09%, flourosis 4.63% and iron deficiency 1.24% (Table 5.20).

The consumption of foods with high carbohydrate content in this study group, as seen from Table 5.4 and 5.5, is high. The incidence of dental caries is known to closely associate with the consumption of highly milled carbohydrates or use of sugars (Jelliffe, 1966). Dental caries occurs with a prevalence of 16.05%, the highest incidence (31.0%) occurs at 5 years of age.

No cases of goitre and parotid gland enlargement were observed in the present study. The absence of goitre may be due to the government's policy of making iodization of common table salt mandatory.

7

Summary and Conclusions

In the present cross-sectional study, an attempt has been made to define the growth pattern and nutritional status of Kisii boys and girls of school-going ages from the rural areas of Keroka Urban Council. Seven anthropometric measurements were taken on each individual. In addition, a clinical survey was carried out. Later most of the subjects were followed to their homes for an ecological survey.

The data presented here comprise of 324 children (164 boys and 160 girls) ranging in ages from 5 through 14 years. From the results obtained, it is evident that as far as their weights and heights are concerned, the Kisii children are below both the 50th NCHS reference values and the Mexican-American children from United States in their growth status. However, they are favourably placed in comparison with three other population groups from East Africa, the Nilo-Hamitic Turkana children (Kenya) and the Bantu Kisi and Nyakyusa children (Tanzania).

Head circumference graph reveals that boys have larger circumference than have girls. In comparison with two other groups, the Nyakyusa and Kisi of Tanzania, the Kisii (Kenya) have larger head circumferences.

Sitting height graph shows that Maxican-Americans have largest sitting height followed by, in decreasing order, the Kisii, and Nyakyusa and Kisi children of Tanzania. Derived leg length values reveal that the Kisii children have longer legs than have Mexican-American, Nyakyusa and Kisi (Tanzania) children.

Mexican-American children have the largest arm circumference and triceps skinfold measurements while the Turkana children have the smallest arm circumference and triceps skinfold measurements. The Kisii children have values that are intermediate. The Mexican-American children also have more fat as revealed by the calculated fat areas. The Kisii children have more fat in comparison with other East African groups, but have muscle areas close to the areas of other groups used for comparison except for the Turkana who have the lowest fat and muscle areas.

Three grades of malnutrition, derived from anthropometric measurements, show that Kisii children are largely marginally malnourished. Clinical observations reveal that Vitamin A deficiency occurred with a frequency of 16.35%, Vitamin B 3.4%, Vitamin C 11.73%, Vitamin D 3.09%, and Iron deficiency 1.24%. Flourosis occurred with a frequency of 4.63% while dental caries occurred with a frequency of 16.05%. Generally, the nutritional status as observed in the present study, when taken sex-wise, is in favour of girls. The present findings when linked with the work of other researchers referred to in the preceding pages points towards such factors as the educational background of the parents, and ecological factors, such as type of house, source and treatment of water before drinking, and health facilities as probable contributors towards poor nutritional status.

Bibliography

1. Adair LS (1985). Marginal intake and maternal adaptation : the case of rural Taiwan. In *Energy Intake and Activity* (ed. E. Pollitt and P. Amante). New York, Liss.

2. Adair LS and Pollitt (1983). Seasonal variation in pre- and post-partum maternal body measurements and infant birth weights. *American Journal of Physical Anthropology,* **62** : 325-331.

3. *Ibid*. (1985). Outcome of maternal nutritional supplementation : a comprehensive review of the Bacon Chow study. *American Journal of Clinical Nutrition,* **41** (5) : 948-978.

4. Adair LS, Pollitt E and Mueller WH. (1983). Maternal anthropometric changes during pregnancy and lactation in a rural Taiwanese population. *Human Biology,* **55** : 771-787.

5. Adams R (1972). Some observations on the interrelations of development and nutrition programme^ *Ecology of Food and Nutrition,* **3** : 85-88.

6. Aggrawal SK (1986). *Geo-Ecology of Malnutrition : A Study of Haryana Children.* Delhi : Inter-India Publications.

7. Amirhakimi GH (1974). Growth from birth to 2 years of rich urban and poor rural Iranian children compared with western norms. *Annals of Human Biology,* **1** : 427-442.

8. Anderson J (1982). *School Lunches in Lesotho.* Maseru : Food and Nutrition Coordination Office.

9. Annegers J (1973). Seasonal food shortages in West Africa. *Ecology of Food and Nutrition*, **2** : 251-257.

10. Apfelbaum M, Bostsarram J and Locatis D (1971). Effect of calorie restriction and excessive calorie intake on energy expenditure. *American Journal of Clinical Nutrition,* **24** : 1405-1409.

11. Ashcroft MT, Heneage P and Lovell HG (1966). Heights and weights of Jamaican school children of various ethnic groups. *American Journal of Physical Anthropology,* **24** : 35-44.

12. Ashworth A (1968). An investigation of very low calorie intakes reported in Jamaica. *British Journal of Nutrition,* **22** : 341-352.

13. Bailey KV (1970). A study of human growth in the framework of applied nutrition and public health nutrition programmes in the Western Pacific region. *Monographs of the Society for Research in Child Development,* **35** : 40-48.

14. Bailey SM, Gershoff SN, McGandy RB, Nondasuta A, Tantiwongse P, *et al*. (1984). A longitudinal study of growth and maturation in rural Thailand. *Human Biology*, **56** : 539-558.

15. Bailey SM, Gershoff SN, McGandy RB, Nondasuta A, Tantiwongse P (1985). Subcutaneous fat remodelling in Southeast Asia infants and children. *American Journal of Physical Anthropology,* **68** : 123-129.

16. Bairagi R. (1980). Is income the only constraint on child nutrition in Bangladesh ? *Bulletin of the WHO*, **58** : 767-772.

17. Balderston JB, Wilson AB, Freire ME and Simonen MS (1981). *Malnourished Children of the Rural Poor*. Boston, Auburn House.

18. Barton WL (1970). Tropical health : a broad survey. In. *Human Ecology in the Tropics* (ed. Garlick, JP and RWJ Keay). pp. 51-58. London : Pergamon Press.

19. Bashir T, MacDonald H and Peacock M (1981). Biochemical evidence of Vitamin D deficiency in pregnant Asian women. *Journal of Human Nutrition,* **35** : 49-52.

20. Baughan B, Demirjian A, Levesque GY and Lapalme-Chapul L (1979). The pattern of facial growth before and during puberty as shown by French-Canadian girls. *Annals of Human Biology,* **6** : 59-64.

21. Baumgartner, RN and Mueller WH (1984). Multivariate analyses of illness data for use in studies on the relationship of physical growth and morbidity. *Human Biology,* **56** : 111-128.

22. Bedi D (1975). Assessment of Malnutrition in Low-Income Group School-children in Chandigarh. MSc Dissertation (unpublished), Panjab University.

23. Behar M (1977). Protein-calorie deficits in developing countries. *New York Academy of Sciences,* **300** : 176-187.

24. Behrend GD (1978). The epidemiology of dental caries and subsistence pattern change. *American Journal of Physical Anthropology,* **48** : 380 (abstract).

25. Belli P (1971). The economic implications of malnutrition : the dismal science revisited. *Economic Development and Cultural Change,* **20** (1) : 1-23.

26. Bengoa, JM, Jelliffe DB and Perez C (1959). Some indicators for broad assessment of the magnitude of PCM in young children in population groups. *American Journal of Clinical Nutrition,* **7** : 714.

27. Berg, A (1981). *Malnourished People : A Policy View.* Washington DC : World Bank.

28. Berlin, E and Markell E (1977). An assessment of the nutritional and healthy status of an Aguaruna Jivaro Community, Amazonas, Peru. *Ecology of Food and Nutrition,* **6** : 69-81.

29. Berlyne GM, Ben Ari J, Nord E and Shainkin R. (1973). Bedouin osteomalacia due to calcium deprivation caused by high phytic acid content of unleavened bread. *American Journal of Clinical Nutrition,* **29** : 910-911.

30. Bielicki T and Welon Z (1982). Growth data as indicators of social inequalities : the case of Poland. *Year book of Physical Anthropology,* **25** : 153-168.

31. Billewicz WZ and McGregor IA (1982). A birth-to- maturity longitudinal study of heights and weights in two West African (Gambian) villages, 1951-1975. *Annals of Human Biology*, **9** : 309-320.

32. Black RE, Brown KH and Becker S (1984). Effects of diarrhea associated with specific enteropathogens on the growth of children in rural Bangladesh. *Paediatrics*, **73** (6) : 799-805.

33. Black S and Sanjur D (1980). Nutrition in Rio Pedras : A study of internal migration and maternal diets. *Ecology of Food and Nutrition*, **10** : 25-33.

34. Blanco AR, Acheson RM, Canosa C and Solomon RB (1974). Height, weight and lines of arrested growth in young Guatemalan children. *American Journal of Physical Anthropology*, **40** : 39-48.

35. Bogin BA and MacVean RB (1978). Growth in height and weight of urban Guatemalan primary school children of low and high socioeconomic class. *Human Biology*, **50** : 477-487.

36. *Ibid* (1981). Nutritional and biological determinants of body fat patterning in urban Guatemalan children. *Human Biology*, **53** : 259-268.

37. *Ibid* (1983). The relationship of socioeconomic status and sex to body size, skeletal maturation, and cognitive status of Guatemalan city school children. *Child Development*, **54** : 115-128.

38. Brazier MAB (ed.) (1975). *Growth and Development of the Brain : Nutritional, Genetic, and Environmental Factors*. New York : Raven.

39. Brown A and Patridge W (1984). *Agricultural policy and child health in rural Mexico*. Presented at annual meetings, American Anthropological Association, Denver, Colorado.

40. Brozek J, Coursin DB and Read MS (1977). Longitudinal studies on the effects of malnutrition, nutritional supplementation, and behavioural stimulation. *Bulletin of Pan American Health Organisation*, **11** :237-249.

41. Brozek J and Schurch B (eds.) (1984). *Malnutrition and Behaviour : Critical Assessment of Key Issues*. Lausanne : Nestle Foundation.

42. Burton BT (1976). *Human Nutrition,* 3rd ed. New York : McGraw-Hill.

43. Buschang PH and Malina RM (1983). Growth in height and weight of mild-to-moderately undernourished Zapotec school children. *Human Biology,* **55** : 587-597.

44. CBS (Central Bureau of Statistics) (1983). *Third Rural Child Nutrition Survey. 1982.* Ministry of Finance and Planning, Nairobi, Kenya.

45. n.d. *1979 Population Census, Volume II, Analytical Report.* Ministry of Finance and Planning, Nairobi, Kenya.

46. Chambers R, Longhurst R and Pacey A (eds.) (1981). *Seasonal Dimensions to Rural Poverty,* London : Pinter.

47. Chang KSF, McmLee MCM, Low WD and Kvan E (1963). Height and weight of Southern Chinese children. *American Journal of Physical Anthropology,* **21** : 497-509.

48. Chavez A, Martinez C, Bourges H, Coronado M, Lopez M *et al.* (1975). Child nutrition problems during lactation in poor rural areas. In. *Nutrition* (ed. Chavez A, Bourges H and Basta S) p. 90 Basel : Karger.

49. Chernichovsky D (1978). *The Economic Theory of the Household and Impact Measurement of Nutrition and Related Health Programmes.* World Bank Staff Working Paper No. 302. Washington, DC : World Bank.

50. Cohen N and Clayden AD (1978). Seasonal variations in weight of children attending an underfives clinic in Lesotho. *Acta Paediatrica Scandinavica,* **67** : 25-31.

51. Colson E (1979). In good years and in bad : Food strategies of self-reliant societies. *Journal of Anthropological Research,* **35** : 18-29.

52. Condon-Paoloni D, Cravioto J, Johnston FE, DeLicardie ER and Scholl TO (1977). Morbidity and growth of infants and young children in a rural Mexican village. *American Journal of Public Health,* **67** : 651-656.

53. Correa H and Cummins G (1970). Contributions of nutrition to economic growth. *American Journal of Clinical Nutrition,* **23** : 560

54. Cox GW (1980). The ecology of famine : An overview. In. *Famine : Its Causes, Effects, and Management,* (ed. Robson JRK) p. 5-18, New York : Gordon and Breach.

55. Cravioto J (1970). Complexity of factors involved in Protein-calorie malnutrition. In : *Gyorgy and Kline (eds.). 1970.* pp. 7-22.

56. Cravioto J, Birch HG, Delicardie ER and Rosales L (1967). The ecology of infant weight gain in a pre-industrial society. *Acta Paediatrica Scandinavica,* **56** : 71-84.

57. Cravioto J, Hambraeus L and Vahlquist B (eds) (1974). *Early Malnutrition and Mental Development,* Uppsala : Almqvist and Wilksell.

58. Crowdy J, Consolazio C, Forbes A, Haisman M and Worsley D (1982). The metabolic effects of restricted food intake on men working in a tropical environment. *Human Nutrition and Applied Nutrition,* **36a** : 325-344.

59. Delgado H, Lechtig A, Yarbrough C, Martorell R, Klein RE and Irwin M (1977). Maternal nutrition : Its effects on growth and development and birthspacing. In. *Moghissi and Evans (eds) 1977.* pp. 133-150.

60. DaMaeyer EM (1976). Early signs of protein-calorie malnutrition. In. *Somogyi, JC and Tashev T (eds.). 1976),* pp. 1-8.

61. Dewalt KM (1983). Income and dietary adequacy in an agricultural community. *Social Science and Medicine,* **17** : 1877-1866.

62. Dewalt KM and Pelto GH (1977). Food use and household ecology in a Mexican community. In. *Nutrition and Anthropology in Action* (ed. Fitzgerald T), pp. 79-93. Assen, The Netherlands : Van Gorcum.

63. Dewey K (1981). Nutritional consequences of the transformation from subsistence to commercial agriculture in Tabasco, Mexico. *Human Ecology,* **9** (2) : 151-187.

64. *Ibid* (1979). Agricultural development, diet, and nutrition. *Ecology of Food and Nutrition,* **8** : 265-273.

65. Dibley KJ, Staehling N, Nieburg P and Trowbridge FL

(1985). Pitfalls in the interpretation of weight-for-height. *XII International Congress of Nutrition,* Brighton, U.K. (abstract).

66. Diesfeld HJ and Hecklau HK (1978). *Kenya : A Geomedical Monograph Series No. 5.* Berlin : Springerverlag.

67. Dufour D. (1984). The food intake and nutritional status of the Tunaon Indians in Northwest Amazon. *American Journal of Physical Anthropology*, **63** (2) : 153 (abstract).

68. Dumont R and Cohen N (1980). *The Growth of Hunger.* London : Boyars.

69. Durnin JVGA, Edholm OG, Miller DS and Waterlow JC (1973). How much food does man require? *Nature*, 242 : 418.

70. Eder J (1978). The caloric returns to food collecting : Disruption and change among the Batak of the Phillipine tropical forest. *Human Ecology,* **6** : 55-69.

71. Edirisinghe JS (1986). Infections in the malnourished : with special reference to malaria and malnutrition in the tropics. *Annals of Tropical Paediatrics*, **6** : 233-237.

72. Edmundson W (1977). Individual variations in work output per unit energy intake in East Java. *Ecology of Food and Nutrition,* **6** : 147-151.

73. *Ibid* (1979). Individual variations in basal metabolic rate and mechanical work efficiency in East Java. *Ecology of food and Nutrition,* **8** : 189-195.

74. *Ibid* (1980). Adaptation to undernutrition : How much food does man need? *Social Science and Medicine,* **14D** : 119-126.

75. El-Nofely AA (1978). Anthropometric study of growth of Egyptian Nubian children. *Human Biology,* **50** : 183-208.

76. Eicher C and Baker D (1982). *Research on Agricultural Development in Sub-Saharan Africa : A Critical Survey.* MSU Int. Dev. Pap. No. 1. Dep. Agric. Econ. East Lansing : Michigan State Univ.

77. Epp H, Killmayer A and Peden D (1984). *Land Use in Kisii District.* KREMU, Technical Report No., 97, Ministry of Finance and Planning, Nairobi, Kenya.

78. Eveleth PB and Tanner JM (1976). *Worldwide Variation in Human Growth.* Cambridge : Cambridge Univ. Press.

79. FAO/WHO (1978). *Requirements for Protein and Energy : An Examination of Current Recommendations.* Report of a group of consultants, Rome : FAO·(Mimeo).

80. Farb P and Armelagos GJ (1980). *Consuming Passions : The Anthropology of Eating.* Boston : Haughton-Mifflin.

81. Ferro-Luzzi A, Norgan N and Durnin J (1975). Food intake in relationship to body weight and age, and its apparent nutritional adequacy in New Guinean Children.. *American Journal of Clinical Nutrition,* **28** : 1443-1453.

82. Fiawoo DK (1975). Physical growth and the social environment : A West African example. In. *Watts et al. (eds.). 1975.* pp. 353-366.

83. Fleuret A (1979). The role of wild foliage plants in the diet : A case study from Lushoto, Tanzania. *Ecology of Food and Nutrition*, **8** : 87-93.

84. Fleuret P and Fleuret A (1980). Nutrition, consumption, and agricultural change. *Human Organisation,* **39** : 250-260.

85. *Ibid* (1983). Socio-economic determinants of child nutrition in Taita, Kenya : A call for discussion. *Culture and Agriculture,* **19** : 8, 16-20.

86. Florencio C (1980). Comparison of the determinants of nutrient intake of rural and urban families. *Ecology of Food and Nutrition,* **10** : 97-104.

87. Fox R (1953). A study of the Energy Expenditure of Africans Engaged in Various rural Activities, with Special Reference to some Environmental and Physiological Factors which may Influence the Efficiency of Their Work. PhD Thesis. London : London Univ.

88. Francois P, Dubois J and Yai E (1983). Energy cost and daily timed activities : An activity index based on Ivory Coast data. *Food and Nutrition,* **9** : 30-37.

89. Frank O and McNicoll G (1987). An interpretation of fertility and population policy in Kenya. *Population and Development Review,* **13** (2) : 209-243.

90. Freeman HE, Klein RE, Townsend JW and Lechtig A (1980). Nutrition and cognitive development among rural Guatemalan children. *American Journal of Public Health,* **70** : 1277-1285.

91. Frisancho AR (1974). Triceps skinfold and upper arm muscle size norms for assessment of nutritional status. *American Journal of Clinical Nutrition,* **27** : 1052-1058.

92. *Ibid* (1978). Nutritional influences on human growth and maturation. *Year book of Physical Anthropology,* **21** : 174-191.

93. *Ibid* (1981). New norms of upper limb fat and muscle areas for assessment of nutritional status. *American Journal of Clinical Nutrition,* **34** : 2540-2545.

94. *Ibid* (1984). Influence of growth status and placental function on birth weights of infants born to young still-growing teenagers. *American Journal of Clinical Nutrition,* **40** : 801-807.

95. Frisancho AR and Garn SM (1971). Skinfold thickness and muscle size : implications for developmental status and nutritional evaluation of children. *American Journal of Clinical Nutrition*, **24** : 541-546.

96. Frisancho AR, Guire K, Babler W, Borkan G and Way A (1980). Nutritional influence on child development and genetic control of adolescent growth of Quechuas and Mestizos from the Peruvian lowlands. *American Journal of Physical Anthropology*, **52** : 367-376.

97. Frisancho AR and Tracer DP (1987). Standards of arm muscle by stature for the assessment of nutritional status of children. *American Journal of Physical Anthropology,* **73** : 459-465.

98. Frisancho AR, Sanchez J, Pallardel D and Yanez L (1973). Adaptive significance of small body size under poor socio-economic conditions in Southern Peru. *American Journal of Physical Anthropology,* **39** : 255-262.

99. Galvin K. (1984). Seasonal variation in diet of the nomadic, pastoral Turkana. *American Journal of Physical Anthropology,* **63** : 159 (abstract).

100. Galvin KA and Little MA (1987). Season patterns of body size and composition among pastoral nomades of Northwestern Kenya. *American Journal of Physical Anthropology,* **72** (2) : 200 (abstract).

101. Garn SM, Rosenberg KR and Schaefer AE (1983). Relationship between fatness level and size attainment in Central America. *Ecology of Food and Nutrition,* **13** : 157-165.

102. Gates-Williams J and Tervalon M (1988). Theoretical models of nutrition and infection : the case of diarrheal diseases. *American Journal of Physical Anthropology* **75** : 212 (abstract).

103. Glazebrook PW and Davis GHG (1979). A review of the interactions of infections and nutrition. *Asian Journal of Infectious Diseases;* **3** : 93-118.

104. Gaulin S and Konner M (1977). On the natural diet of primates, including man. In : *Wurtman and Wurtman (eds.). 1977*, pp. 2-86.

105. Goldstein M (1936). Changes in dimensions and form of the face and head with age. *American Journal of Physical Anthropology,* **22** : 37-89.

106. Goldstein H and Tanner JM (1980). Ecological considerations in the creation and the use of child growth standards. *Lancet*, **1** : 582-585.

107. Gomez F, Galvan RR, Frenk S, Munoz JC, Chavez R and Vasquez J (1956). Mortality in second and third degree malnutrition. *Journal of Tropical Paediatrics,* **2** : 77-83.

108. Gordon JE, Ascoli W, Mata LJ, Guzman MA and Scrimshaw NS (1968). Nutrition and infection field study in Guatemalan villages, 1959-1964. VI : Acute diarrheal disease and nutritional disorders in general disease incidence. *Archives of Environmental Health*, **16** : 424.

109. Grahman GG, Jr MacLean WC, Kallman CH, Rabold J and Mellits ED (1980). Urban-rural differences in the growth of Peruvian children. *American Journal of Clinical Nutrition.* **33** : 338-344.

110. Grant MW (1951). Technique for the analysis of height and weight data in tropical countries. Mimeographed notes, London School of Hygiene and Tropical Medicine.

111. Grivetti L (1979). Kalahari agro-pastoralist-hunter-gatherers : The Tswana example. *Ecology of Food and Nutrition*. **7** : 235-236.

112. Gross DR (1975). Protein capture and cultural development in the Amazon Basin. *American Anthropologist*. **77** : 526-549.

113. Gross DR, and Underwood BA (1971). Technological change and caloric costs: Sisal agriculture in Northeast Brazil. *American Anthropologist*. **73** : 725-740.

114. Gurney JM and Jelliffe DB (1973). Arm anthropometry in nutritional assessment : nomogram for rapid calculation of muscle circumference and cross-sectional muscle and fat areas. *American Journal of Clinical Nutrition*. **26** : 912-915.

115. Guthrie GM, Guthrie HA, Fernandez TL and Estrera N (1983). Early termination of breastfeeding among Phillipine urban poor. *Ecology of Food and Nutrition*. **12** : 195-202.

116. Gyorgy P and Kline OL (eds) (1970). *Malnutrition is a Problem Ecology*. Basel : Karger.

117. Haas JD (1983). Nutrition and high altitude adaptation : an example of human adaptability in a multistress environment. In : *Rethinking Human Adaptation : Biological and Cultural Models*, (ed. Dyson-Hudson, R and MA Little), pp. 41-56. Boulder : Co. Westview Press.

118. Haas JD, and Harrison GG (1977). Nutritional anthropology and biological adaptation. *Annual Review of Anthropology*, **6** : 69-101.

119. Habicht JP, Meyers LD and Brownie C (1982). Overview : indicators for identifying and counting the improperly nourished. *American Journal of Clinical Nutrition*. **35** : 1241-1254.

120. Habicht JP, Yarbrough C, Martorell R, Malina RM and Klein RE (1974). Height and weight standards for pre-school children. *Lancet*, **1** : 611-614.

121. Hamill PVV, Johnson CL, Reed RB and Roche AF (1977).

NCHS growth curves for children birth-18 years. Publ. (PHS), 78-1650. Hyattsville, MD : NCHS.

122. Hanks L (1972). *Rice and Man*. Arlington Heights. IL : AHIM Publ.

123. Harris B, and Harris J (1982). Development studies. *Programmes in Human Geography,* 6 : 584-592.

124. Harrison GA, Weiner JS, Tanner JM and Barnicot NA (1977). *Human Biology : An Introduction to Human Evolution, Variation, Growth and Ecology*, 2nd ed. pp. 400-423. Oxford : Oxford University Press.

125. Harvey PW and Heywood PF (1983). Twenty-five years of dietary change in Simbu Province, Papua New Guinea. *Ecology of Food and Nutrition,* 13 : 27-35.

126. Haswell M (1953). *Economics of Agriculture in a Savanna Village.* Colonial Research Study No. 8. London : HMSO.

127. Hausman A and Wilmsen E (1984). Impact of seasonality of food on growth and fertility. *American Journal of Physical Anthropology,* 63 : 169 (abstr.).

128. Hauspie R (1980) Adolescent growth. In. *Johnston et al., 1980b*. pp. 161-175.

129. Hauspie RC, Das SR, Preece MA and Tanner JM (1980). A longitudinal study of the growth in height of boys and girls of West Bengal (India) age six months to 20 years. *Annals of Human Biology*, 7 : 429-440.

130. Hautvast J (1971a). Growth in stature and head and face measurements in Dutch children aged 7 to 14. *Human Biology*, **43** (3) : 340-343.

131. *Ibid*. (1971b). Physical growth and menarcheal age in Tanzanian School children and adults. *Human Biology*, **43** : 421-444.

132. Hiernaux J. (1970). Interpopulation variation in growth, with special reference to sub-Saharan Africa. *Monographs of the Society for Research in Child Development,* **37** (7) : 74-77.

133. Himes JH and Malina RM (1975). Age and secular factors in the stature of adult Zapotec males. *American Journal of Physical Anthropology,* **43** : 367-370.

134. Himes JH, Malina RM and Stepick CD (1976). Relationship between body size and second children 6 to 14 years of age. *Human Biology*, **48** : 677-692.

135. Himes JH and Mueller WH (1977). Aging and secular change in adult stature in rural Colombia. *American Journal of Physical Anthropology*, **46** : 275-280.

136. Hofvander Y and Petros-Barvazian A (1978). WHO collaborative study on breastfeeding. *Acta Paediatrica Scandinavica*, **67** : 556-560.

137. Huffman S (1984). Determinants of breastfeeding in developing countries : overview and policy implications. *Studies in Family Planning.* **15** (4) : 170-183.

138. Hunter JM (1967). Seasonal hunger in part of the West African Savanna : a study of Nangodi, Northeast Ghana. *Transcripts of the Institute of British Geography,* **41** : 167-185.

139. Huss-Ashmore R (1980). Fat and fertility : demographic implications of differential fat storage. *Year book of Physical Anthropology,* **23 :** 65-91.

140. *Ibid* (1982). Seasonality in rural highland Lesotho : Method and policy. In. *A Report on the Regional Workshop on Seasonal Variations in the Provisioning, Nutrition and Health of Rural Families.* Nairobi, AMREF.

141. *Ibid* (1984). Seasonal cycles of nutrition and resource procurement in Lesotho. *American Journal of Physical Anthropology,* **63** (2) : 173 (abstract).

142. Huss-Ashmore R and Johnston FE (1985). Bioanthropological research in developing countries. *Annual Review of anthropology,* **14** : 475-528.

143. ICMR (Indian Council of Medical Research) (1972). *Growth and Physical Development of Indian Infants and Children.* Technical Report No. 18. New Delhi : ICMR.

144. International Centre for Research on Women (1980). *The Productivity of Women in Developing Countries : Measurement, Issues and Recommendations.* Office of Women Development. Washington. DC : USAID.

145. International Union of Nutritional Sciences (1971). The

creation of growth standards : a committee report of a meeting in Tunis. *American Journal of Clinical Nutrition*, **25** : 218-220.

146. Jackson L and Jackson R (1984). Health implications of chronic dietary cyanide ingestion. *American Journal of Physical Anthropology*, **63** : 174 (abstract).

147. James W and Shettey P (1982). Metabolic adaptations and energy requirements in developing countries. *American Journal of Clinical Nutrition*, **36** : 331-336.

148. Jelliffe DB (1966). *The Assessment of the Nutritional Status of the Community*. WHO Monograph Series No. 53. Geneva : WHO.

149. Jelliffe DB and Jelliffe EFB (eds) (1979). *Nutrition and Growth*. New York : Plenum.

150. Jenkins CL (1981). Patterns of growth and malnutrition among preschoolers in Belize. *American Journal of Physical Anthropology*, **56** : 169-178.

151. *Ibid* (1982). Factors in the etiology of poor growth in Belize. *Cajanus*, **15** : 172-184.

152. *Ibid* (1984). Nutrition and growth in early childhood among the Garifuna and Creole Belize. In. *Current Developments in Anthropological Genetics : Black Carribs : A case study in Biocultural Adaptations*. (ed. Crawford, MH), Vol. 3. pp. 135-137. New York : Plenum Press.

153. Johnson CL, Fulwood R, Abraham S and Bryner JD (1981). Basic data on anthropometric measurements and angular measurements of the hip and knee joints for selected groups 1-74 years of age. (PHS) 81-1669. Hyattsville, MD : US Deptt. Health and Human Resources.

154. Johnston FE (1981a). Anthropometry and nutritional status. In. *Assessing Changing Food Consumption Patterns*. National Research Council. pp. 252-264. Washington DC : National Academic Press.

155. *Ibid*. (1981b). Physical growth and development : Epidemiological considerations. *Federal Proceedings*, **40** : 2583-2587.

156. *Ibid* (1985). Reference data for physical growth in nutritional anthropometry. In : *Training Manual in Nutritional Anthropology* (eds. Quandt S, and Ritenbaugh C) Wasington DC : American Anthropological Association.

157. Johnston FE, Bogin BA, MacVean RB and Newman BC (1984a). A comparison of international standards versus local reference data for the triceps and subscapular skinfolds of Guatemalan children and youth. *Human Biology*, **56** : 157-171.

158. *Ibid* (1984b). A comparison of international standards versus local reference data for the triceps and subscapular skinfolds of Guatemalan children and youth. *Human Biology*, **56** : 143-156.

159. Johston FE, Borden M and MacVean RB (1973). Height, weight, and their growth velocities in Guatemalan private school children of high socioeconomic class. *Human Biology*, **45** : 627-641.

160. *Ibid* (1975a). The effects of genetic and environmental factors upon the growth of children in Guatemala city. In : *Watts et al. (eds.). 1975*. pp. 377-388.

161. Johnston FE, Dechow PC and MacVean RB (1975b). Age changes in skinfold thickness among upper class children of differing ethnic backgrounds residing in Guatemala. *Human Biology*, **47** : 251-262.

162. Johnston FE, Low SM, De Baessa Y and MacVean RB (1985). Growth status of disadvantaged urban Guatemalan children of a resettled community. *American Journal of Physical Anthropology*, **68**: 215-224.

163. *Ibid* (1987). Interaction of nutritional and socioeconomic status as determinants of cognitive development in disadvantaged urban Guatemalan children. *American Journal of Physical Anthropology*, **73** : 501-506.

164. Johnston FE, Roche AR and Sussane C (eds.) (1980b). *Human Physical Growth and Malnutrition : Methodologies and Factors.* New York : Plenum Press.

165. Johnston FE, Scholl TO, Newman BC, Cravioto J and DeLicardie ER (1980a). An analysis of environmental

variables and factors associated with growth failure in a Mexican village. *Human Biology,* **52** : 627-637.

166. Johnston FE, Weiner H, Thissen D and MacVean RB (1976). Hereditary and environmental determinants of growth in height in a longitudinal sample of children and youth of Guatemalan and European ancestry. *American Journal of Physical Anthropology,* **44** : 469-476.

167. Jordan J, Reuben M, Hernandez J, Bebelagua A, Tanner JM and Goldstein H (1975). The 1972 Cuban national child growth study as an example of population health monitoring : Design and methods. *Annals of Human Biology,* **2** : 153.

168. Kanawati AA and McLaren DS (1970). Assessment of marginal malnutrition. *Nature,* **228** : 573-574.

169. *Ibid* (1973). Failure to thrive in Lebanon. II. An investigation of the causes. *Acta Paediatrica Scandinavica*, **62** : 571-576.

170. Katz S (1982). Food, behaviour, and biocultural evolution. In : *The Psychology of Human Food Selection* (ed. Baker L.) pp. 171-188. Westport, Conn : Avi.

171. Kaul SS (1971). Physical Growth and Development (Human) -- A study based on Kashmiri Pandit boys of school-going age in Srinagar, Kashmir. PhD Thesis (unpublished), Panjab University.

172. *Ibid* (1975). Growth in three anthropometric measures of Kashmiri Pandit school-going boys with some observations on the efficiency of mixed-longitudinal analysis of human growth. *Indian Journal of Medical Research,* **63** (4) : 590-596.

173. *Ibid* (1983). Growth studies in children editorial. *Indian Paediatrics,* **20** : 391-394.

174. Kaul SS and Corruccini RS (1989). Secular change in height of Indian adolescents of Punjabi origin. Presented at the UGC Seminar-New Horizons of Human Biology, Punjabi University, Patiala (Nov. 9-10, 1989).

175. Keller W and Filmore CM (1988). Prevalence of protein energy malnutrition. *World Health Statistical Quarterly,* **36** : 129-167.

176. Keys A, Brozek J, Henschel A, Mickelson O and Taylor H

(1950). *The Biology of Human Starvation.* Mineapolis. Univ. Minn. Press.

177. Lampl M, Johnston FE and Malcolm LA (1978). The effects of protein supplementation on the growth and skeletal maturation of New Guinean School children. *Annals of Human Biology,* **5** : 219-227.

178. Latham M (1975). Nutrition and infection in national development. *Science,* **188** :589-593.

179. *Ibid* (1979). *Human Nutrition in Tropical Africa,* 2nd ed. Rome : FAO.

180. Lechtig A, Delgado H, Lasky R, Yarbrough C and Klein RE *et al.* (1975). Maternal nutrition and fetal growth in developing countries. *American Journal of Disease in Children,* 129 : 553-556.

181. Leonard WR (1987). Energy intake and expenditure in southern Peruvian Highlands. *American Journal of Physical Anthropology,* **72** (2) : 224 (abstract).

182. Linares O (1976). "Garden hunting" in the American tropics. *Human Ecology,* **4** : 331-350.

183. Little MA (1980). Designs for human biological research among savannah pastoralists. Ih : *Human Ecology in Savanna Environments,* (ed. Harris DR), pp. 479-503. Academic Press, London.

184. Little MA, Galvin K and Mugambi M (1983). Cross-sectional growth of nomadic Turkana Pastoralists. *Human Biology,* **55** : 811-830.

185. Little MA and Morren GEB Jr (1976). *Ecology, Energetics and Humand Variability.* Dubuque : WM.C. Brown.

186. Lloyd JK, Wolff DH and Whelen WS (1961). A long term study of height and weight. *British Medical Journal,* **15** : 145.

187. Malcom LA (1975). Some biosocial determinants of the growth, health, and nutritional status of Papua New Guinean pre-school children. In : *Watts, ES, FE Johnston and GW Gabriel (eds.), 1975.* pp. 367-376.

188. Malina RM, Buschang PH, Aronson WL and Selby HA.

(1982). Childhood growth status of eventual migrants and sedentes in a rural Zapotec community in the valley of Oaxaca, Mexico. *Human Biology*, **54** : 709-716.

189. Malina RM and Chumlea C (1980). Re-examination of the age at menarche in Oaxaca, Mexico. *Annals of Human Biology*, **7** : 281-283.

190. Malina RM, Chumlea C, Stepick CD and Lopez FG (1977). Age of menarche in Oaxaca, Mexico, Schoolgirls, with comparative data from other areas of Mexico. *Annals of Human Biology*, **4** : 551-558.

191. Malina RM, Habicht JP, Yarbrough C, Martorell R and Klein RE (1974). Skinfold thickness at seven sites in rural Guatemalan Ladino children from birth through 7 years of age. *Human Biology*, **46** (3) : 453-469.

192. Malina RM and Himes JH (1977a). Seasonality of the births in a rural Zapotec-speaking Municipio, 1945-1970. *Human Biology*, **49** : 125-137.

193. *Ibid* (1977b). Differential age effects in seasonal variation of mortality in a rural Zapotec-speaking Municipio, 1945-1970. *Human Biology*, **49** : 415-428.

194. Malina RM, Little BB, Buschang PH, DeMoss J, and Selby HA (1985). Socioeconomic variation in the growth study of children in a subsistence agricultural community. *American Journal of Physical Anthropology*, **68** : 385-391.

195. Martorell R, Delgado H, Valverde V and Klein RE (1981). Maternal stature, fertility, and infant mortality. *Human Biology*, **53** : 303-312.

196. Martorell R, Klein RE and Delgado H (1980). Improved nutrition and its effects on anthropometric indicators of nutritional status. *Nutrition Report International* **21** : 219-230.

197. Martorell R, Malina RM, Castillo RO, Mendoza FS and Pawson IG (1988). Body proportions in three ethnic groups : Children and youths 2-17 years in NHANES II and HHANES. *Human Biology*, **60** : 205-222.

198. Martorell R, Mendoza FS, Castillo RO, Pawson IG and Budge CC (1987). Short and plump physique of Mexican-American children. *American Journal of Physical Anthropology*, **73** :475-487.

199. Martorell R, Yarbrough C, Lechtig A, Delgado H and Klein RE (1977). Genetic-environmental interactions in physical growth. *Acta Paediatrica Scandinavica*, **66** : 579-584.

200. Martorell R, Yarbrough C, Lechtig A, Habicht JP and Klein RE (1975a). Diarrheal diseases and growth retardation in Pre-school Guatemalan children. *American Journal of Physical Anthropology*, **43** : 341-346.

201. Martorell R, Yarbrough C, Malina RM, Habicht JP, Lechtig A and Klein RE (1975b). The head circumference/chest circumference ratio in mild-to-moderate protein calorie malnutrition. *Environment and Child Health* **20** : 203-207.

202. Mata LJ (1977). Environmental determinants and origins of malnutrition. In. *Suskind, RM. (ed.) 1977.* pp. 9-20.

203. *Ibid* (1978). Breastfeeding : main promoter of infant health. *American Journal of Clinical Nutrition,* **34** : 2058-2065.

204. Mata L, Urrutia JJ and Lechtig A (1971). Infection and nutrition of children of a low socioeconomic rural community. *American Journal of Clinical Nutrition,* **24** : 249-259.

205. McGregor IA, Rahaman AK, Thompson B, Billewicz WZ and Thomson AM (1968). The growth of young children in a Gambian village. *Transactions of the Royal Society for Tropical Medicine and Hygiene,* **62** :341-352.

206. McLaren D (1976). *Nutrition and its Disorders.* 2nd ed. Edinburgh : Churchill Livingston.

207. McLaren DS and Read WW. (1972). Classification of nutritional status in early childhood. *Lancet,* **2** : 146-148.

208. Meredith HV (1969). Body size of contemporary groups of eight year old children. Studies in different parts of the world. *Monographs of the Society for Research in Child Development*, **34** : 1-50.

209. *Ibid* (1971). Human head circumference from birth to early adulthood : Racial, regional and sex comparisons. *Growth,* **35** : 233-251.

210. *Ibid.* (1976). Findings from Asia, Australia, Europe and North America on secular change in mean height of

children, youths and young adults. *American Journal of Physical Anthropology.* **44** : 315-326.

211. Messer E (1984). Anthropological perspectives on diet. *Annual Review of Anthropology,* **13** : 205-249.

212. Miklashevskaya NN (1969). Sex differences in growth of the head and face in children and adolescents., *Human Biology,* **41** : 250-262.

213. Moghissi K, and Evans T (ed.) (1977). *Nutritional Impacts on Women Throughout Life with Emphasis on Reproduction.* Hagerstown; MD : Harper & Row.

214. Monteiro, CA (1985). A critical assessment of recently proposed changes in anthropometric evaluation of nutritional status of children. *XII International Congress of Nutrition,* Brighton, U.K. (abstract).

215. Mora JO, Harrera MG, Suescun J, Navarro L de and Wagner M (1981a). The effects of nutritional supplementation on physical growth of children at risk of malnutrition. *American Journal of Clinical Nutrition,* **34** : 1885-1892.

216. Mora JO, Sellers SG, Suescun J and Herrera MG (1981b). The impact of supplementary feeding and home education on physical growth of disadvantaged children. *Nutrition Research,* **1** : 213-225.

217. Moren-Black G (1983). Dietary status and dietary diversity of native highland Bolivian children. *Ecology of Food and Nutrition,* **13** : 149-156.

218. Morley D, and Woodland M (1979). *See How They Grow : Monitoring Child Growth for Appropriate Health Care in Developing Countries*. New York : Oxford University Press.

219. Moss NH. and Mayer J (eds.) (1977). *Food and Nutrition in Health and Disease. Annuals of New York Academy of Sciences,* **300** : 1-474.

220. Mueller WH (1976). Parent-child correlations for stature and weight among school aged children : a review of 24 studies. *Human Biology,* **48** : 379-397.

221. NCHS (National Centre for Health Statistics) (1977). NCHS

growth curves for children, birth to 18 years, United States, *Vital and Health Statistics*, Series 11, No. 165.

222. Nellhaus G (1968). Head circumference from birth to eighteen years : practical composite international and interracial graphs. *Pediatrics,* **41** : 106-114.

223. Nestle M (1981). Nutrition. In. *Harper's Review of Biochemistry* (eds.), Martin DW, Mayers PA and Rodwell VW) 18th ed. p. 574. Los Altos : California Lange Medical Publs.

224. Newman MT (1962). Ecology and nutritional stress in man. *American Anthropologist,* **64** (1) : 22-34.

225. *Ibid*. (1977). Ecology and nutritional stress. In. *Culture, Disease and Healing*. (ed.) Landy D pp. 319-326. New York : McMillan

226. Newman J (1980). Dimensions of Sandawe diet. In. *Robson, 1980*. pp. 27-34.

227. Ochieng WL (1974). *A Pre-colonial History of the Gusii of Western Kenya from c.A.D. 1500-1914*. Nairobi : East Africa Literature Bureau.

228. Ogbu J (1973). Seasonal hunger in tropical Africa as a cultural phenomenon. *Africa,* **43** (4) : 317-332.

229. Olness K, Yip R, Indritz A and Torjesen E (1984). Height and weight status of Indo-Chinese refugee children : an anthropometric study of 1,650 children. *American Journal of Disease in Children,* **138** : 544-547.

230. Oomen H and Grubben G (1981). Leaves : an underrated source of nutrients. *Development Digest,* **19** (2) : 49-58.

231. Orr JB and Gilks JL (1931). Studies of nutrition : the physique and health of two African tribes. *Medical Research Council (Gr. Britain), Special Report Series,* **155** : 1-93.

232. Osuhor PC (1980). Weaning Practices amongst the Hausas. *Journal of Human Nutrition,* **34** (4) : 273-279.

233. Ottenberg S and Ottenberg P (1960). *Cultures and Societies of Africa*, p. 6. New York : Random House.

234. Patridge W, Brown A and Nugen J (1982). The Papalaopan

Dam and Resettlement Project : Human ecology and health impacts. In. *Involuntary Migration and Resettlement.* (ed. Hanson A & Oliver-Smith) Boulder : Westview.

235. Peckos PC (1953). Calorie intake in relation to physique in children. *Science,* **117** : 631.

236. Pellett P (1976). Role of food mixtures in combating childhood malnutrition. In. *Nutrition in the Community.* (ed. McLaren D. pp. 185-202. Chichester : Wiley.

237. *Ibid* (1982). Changing concepts on world malnutrition. *Ecology of Food and Nutrition,* **13** : 115-125.

238. Pharaon HM (1970). The influence of ecological factors on malnutrition in the middle East. In : *Gyorgy and Kline* (eds.), 1970). pp. 73-82.

239. Picon-Reatigui E (1976). Nutrition. In. *Man in the Andes (ed.* Baker DT and Little MA. Strousberg, PA : Dourden, Hutchinson and Ross.

240. Pinstrup-Andersen P (1981). *Nutritional Consequences of Agricultural Projects : Conceptual Relationships and Assessment Approaches.* Staff Working Paper No. 456. Washinton D.C. : World Bank.

241. Pollitt E and Mueller WH (1982). Maternal supplementation during pregnancy interferes with physical resemblance of siblings at birth according to infant sex. *Early Human Development,* **7** : 251-256.

242. Popkin BM, Bilsborrow RE and Akin JS (1982). Breastfeeding patterns in low-income countries. *Science,* **218** : 1088-1093.

243. Quandt S. (1986). Methods for determining dietary intake. In : *Nutrition in Biological Anthropology* (ed. FE Johnston). New York : Liss.

244. Raghavan KV, Singh D, and Swaminathan MC (1971) Heights and weights of well nourished Indian School Children. *Indian Journal of Medical Research,* **59** : 648-654.

245. Rao DH and Satyanarayana K (1976). Nutritional status of people of different socioeconomic groups in a rural area with special reference to pre-school children. *Ecology of Food and Nutrition.* **4** : 237.

246. Rea JN (1971). Social and economic influences on the growth of pre-school children in Lagos. *Human Biology,* **43** : 46-63.

247. Reddy V, Jagadeesan V, Rhagaramulu N, Bhaskaram C and Srikantia SG (1976). Functional significance of growth retardation in malnutrition. *American Journal of Clinical Nutrition,* **29** : 3-7.

248. Reichel-Dolmatoff G (1976). Cosmology as ecological analysis : A view from the rain forest. *Man,* **11** : 307-318.

249. Richard P (1983). Ecological change and the politics of African land use. *African Studies Review,***26** : 1-72.

250. Robson J (ed.) (1980). *Food, Ecology and Culture,* New York : Gordon & Breach.

251. Ronaghy H, and Halsted J (1975). Zinc deficiency occurring in females : Report of two cases. *American Journal of Clinical Nutrition,* **28** : 831-836.

252. Ryan AS and Martinez GA (1987). Physical growth of infants 7 to 13 months of age : results from a national survey. *American Journal of Physical Anthropology,***73** : 449-457.

253. Sabharwal KP, Morules S and Mendez J (1966). Body measurements and creatinine excretion among upper and lower socio-economic groups of girls of Guatemala. *Human Biology,***38** : 131-140.

254. Satyanarayana K, Naidu AN, Chatarjee E and Rao BSN (1977). Body size and work output. *American Journal of Clinical Nutrition,* **30** : 322-325.

255. Schlegel S and Guthrie H (1980). Diet and the Tiruray shift from swidden to plough farming. In. *Robson (1980).* pp. 9-20.

256. Schofield S (1974). Seasonal factors affecting nutrition in different age groups and especially pre-school children. *Journal of Development Studies,***11** (1) : 22-40.

257. *Ibid.* (1979). *Development and the Problem of Village Nutrition.* Institute of Development Studies. Sussex. London : Croom Heln.

258. Scholl TO (1975). Body size in Developing Nations : Is Bigger Better? PhD Thesis. Philadelphia : Temple Univ.

259. Scholl TO, Johnston FE, Cravioto J, DeLicardie ER and Lurie DS (1979). The relationship of growth failure (chronic under-nutrition) to the prevalence of clinically severe protein energy malnutrition and to growth retardation in protein energy malnutrition. *American Journal of Clinical Nutrition,* **32** : 872-878.

260. Scrimshaw NS, Taylor C and Gordon J (1968). *Interactions of Nutrition and Infection.* WHO Monograph Series No. 57, Geneva : WHO.

261. Sellers SG, Mora JO, Super CM and Herrera MG (1982). The effects of nutritional supplementation and home education on children's diets. *Nutrition Report International,* **26** : 727-740.

262. Sheffer ML, Grantham-McGregor S and Ismail SJ (1981). The social environment of malnourished children compared with that of other children in Jamaica. *Journal of Biosocial Sciences,* **3** : 19-30.

263. Shorter A (1974). *East African Societies.* Routledge & London : Kegan Paul.

264. Sidhu LS, Bhatnagar DP and Dubey AP (1982). Secular trends in heights and weights of Punjabi boys. *Anthropologischer Anzeiger,* **40** : 187-192.

265. Simopoulos AP (ed.) (1982). Assessment of Nutritional Status. *American Journal of Clinical Nutrition,* **35** :1089-1325.

266. Singh SP and Malhotra P (1968). Secular shift in menarcheal age of Patiala (India) schoolgirls between 1974 and 1986. *Annals of Human Biology,* **15** : 77-80.

267. Somogyi JC and Tashev T. (eds.) (1976). *Early Signs of Nutritional Deficiencies.* Basel : Karger.

268. Spencer T and Heywood P (1983). Seasonality, subsistence agriculture, and nutrition in a lowlands community of Papua New Guinea. *Ecology of Food and Nutrition,* **13** : 221-229.

269. Srinivasan T (1980). *Malnutrition : Some Measurement and Policy Issues.* Staff working paper No. 373. Washington D.C. World Bank.

270. Stini WA (1969). Nutritional stress and growth : sex

differences in adaptive response. *American Journal of Physical Anthropology,* **31** : 417-426.

271. *Ibid.* (1975). Adaptive strategies of human populations under nutritional stress. In : *Watts et al (eds.) 1975,* pp. 19-42.

272. Strong F (1976). Toxicants occurring naturally in foods. In : *Present Knowledge in Nutrition* (ed DM Hegsted) 4th ed. pp. 516-527. New York : Nutr. Found.

273. Stuart HC and Stevenson SS (1963). General factors in care and evaluation of children. In. *Textbook of Paediatrics* (ed. Nelson WE) pp. 12-49. Philadelphia : Saunders.

274. *Ibid* (1969). Growth and development. In. *Textbook of Paediatrics* (ed.), Nelson WE) 9th ed. Philadelphia : W.B. Saunders.

275. Sukhatme P and Margen S (1982). Autoregulatory homeostatic nature of energy balance. *American Journal of Clinical Nutrition,* **35** : 335-365.

276. Sukkar MY, Kemm JR, Ballal MA and Ahmed TA (1980). Growth velocity in children in rural Khartoum, Sudan. *Annals of Human Biology,* **7** : 473-480.

277. Suskind RM (ed.) (1977). *Malnutrition and the Immune Response*. New York : Raven.

278. Sussane C (1980). Socio-economic differences in growth patterns. In. *FE Johnston, Roche AF, and Sussane C (eds.), 1980 (b).* pp. 329-338.

279. Tanner JM (1962). *Growth at Adolescence.* 2nd edition, Oxford : Blackwell.

280. *Ibid.* (1966). The secular trend toward earlier maturation. *Tijdschrift Voor Sociale Geneeskunde,* **44** : 525-539.

281. *Ibid* (1976). Growth as a monitor of nutritional status. *Proceedings of the Nutrition Society,* **35** : 315-322.

282. Tanner JM, Whitehouse RH and Takaishi M. (1965). Standards from birth to maturity for height, weight, height velocity, and weight velocity : British children. *Archives of Disease in Childhood,* **41** : 454-464.

283. Taussig M (1978). Peasant economics and the development

of capitalist agriculture in the Cauca Valley, Colombia. *Latin American Perspective,* **5** : 27-37.

284. Taylor HL and Keys A (1950). Adaptation to calorie restriction. *Science*, **112** : 215-218.

285. Teitelbaum J (1977). Human Vs Animal nutrition : A "development" project among Fulani cattlekeepers of the Sahel of Senegal. In. *Nutrition and Anthropology in Action,* (ed. T. Fitzgerald) pp. 125-140. Assen. The Netherlands : Van Gorcum.

286. Thomas RB (1975). The ecology of work. In. *Physiological Anthropology*, ed. A Damon. pp 55-79. New York : Oxford Univ. Press.

287. Thomson A and Hytten F (1977). Physiological basis of nutritional needs during pregnancy and lactation. In. *Moghissi and Evans* (eds.), **1977**. pp. 10-22.

288. Torry W (1984). Social science research in famine : A critical evaluation. *Human Ecology*, **12** : 227-252.

289. Trowbridge FL (1979). Clinical and biochemical characteristics associated with anthropometric nutritional categories. *American Journal of Clinical Nutrition,* **32** : 758-766.

290. UN (United Nations) (1985). *World Population Prospects : Estimates and Projections as Assessed in 1982.* New York : UN.

291. Underwood B (1980). Conferences review : New research. *Mothers and Children,* **1** (1) : 1-5.

292. *Ibid* (1983). *Nutrition Intervention Strategies in National Development*. New York : Academic.

293. Van Wering ER (1981a). The secular growth trend in Aruba between 1954 and 1974. *Human Biology,* **53** : 105-116.

294. *Ibid* (1981b). The anthropometric status of Aruban children 1974. *Human Biology*, **53** : 117-136.

295. Vijayaraghavan K, Singh D and Swaminathan MC (1971). Heights and weights of well-nourished Indian School children. *Indian Journal of Medical Research*, **59** : 648-654.

296. Waldermann E (1973). Seasonal variations in malnutrition

in Africa. *Royal Society of Tropical Medicine and Hygiene,* **67** : 431.

297. *Ibid* (1980). The ecology of the nutrition of the Bapedi, Sekhukuniland. In *Robson (1980)*, pp. 47-60.

298. Wale O and Rodrigues AM (1980). Nutrition considerations in a cassava production programme for Guyana. *Ecology of Food and Nutrition*, **10** : 87-95.

299. Waterlow JC (1984). Current issues in nutritional assessment by anthropometry. In. *Brozek and Schurch (eds.) 1984*, pp. 77-90.

300. Waterlow JC, Buzina R, Keller W, Lane JM, Nichama MZ and Tanner JM (1977). The presentation and use of height and weight data for comparing the nutritional status of groups of children under 10 years. *Bulletin of the WHO*, **55** : 489-498.

301. Watts ES, Johnston FE and Gabriel GW. (eds) (1975). *Biosocial Interrelations in Population Adaptation* The Hague : Mouton.

302. Weiner JS and Lourie JA (1969). *Human Biology : a Guide to Field Methods.* Oxford : Blackwell Scientific Publications.

303. Winkler EM and Sokal RR (1987a). Phenetic classification of Kenyan tribes and subtribes. *Human Biology,* **59** : 121-145.

304. Wolff OH. (1955). Obesity in childhood : a study of the birth weight, the height and the onset of puberty. *Quarterly Journal of Medicine,* **24** : 109.

305. Woolfe J, Wheeler EF, Van Dyke W and Orraca-Tetteh R. (1977). The value of the Ghanian traditional diet in relation to the energy needs of young children. *Ecology of Food and Nutrition,* **6** : 175-181.

306. Wurtman R and Wurtman J (eds) (1977). *Nutrition and the Brain.* New York : Raven.

307. Yarbrough C, Habicht JP, Malina RM, Lechtig A and Klein RE (1975). Length and weight in rural Guatemalan Ladino children : birth to 7 years of age. *American Journal of Physical Anthropology*, **42** : 439-448.

308. Zavaleta AN and Malina RM (1980). Growth, fatness, and leanness of Mexican-American children. *American Journal of Clinical Nutrition,* **33** : 2008-2020.

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